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THE

BULLETIN

OF THE

UNIVERSITY OF NEW MEXICO

VOLUME I.

EDITED BY C. L. HERRICK, PH. D.

[CONT[illegible]NG CONTRIBUTIONS FROM THE UNIVERSITY GEOLOGICAL
SURVEY AND THE HADLEY CLIMATOLOGICAL LABORATORY].

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INTRODUCTION.

The present volume is simply a collection of a part of the publications of the laboratories of the University of New Mexico for the past year. The papers included have been printed in various periodicals and the reprints accordingly are not uniform in type or in pagination. A word may be said respecting the geological papers here collected. These notes on the geological work done in intervals of time purport to be no more than preliminary reports in preparation for future work. No economic questions have been touched upon for two reasons. First, it is expected to prepare a series of volumes on the economic geology of the Territory in connection with the geological survey inaugurated by the University. Second, these articles, having been printed in eastern magazines, could not be expected to interest the general reader in matters more appropriate to our own region. Economic questions have not been neglected and will receive due attention in following volumes. The publication of the results of the survey, it is expected, will be incorporated with those of the Hadley Climatological Laboratory. The citizens of the Territory are earnestly appealed to to assist in the work of the survey by affording information of interest so that the work may be turned in lines of immediate importance. We especially desire information regarding the situation, amount, fluctuations and nature of all springs, flowing water, lakes and wells in the Territory. The owners of wells or tanks for irrigation will confer a or by supplying such data.

As the corps of the Hadley Laboratory and geological irvey are interesting themselves in questions relating to disease in the plateau they especially request information relating to epidemic or prevailing diseases among cattle or wild animals or plants, especially at present the disease known as "loco" in cattle and "roupe" in fowls.

As a matter of general interest the following outline of the work of the Hadley Laboratory is subjoined.

THE HADLEY CLIMATOLOGICAL LABORATORY.

This department of the work of the University is an organization for research especially with reference to the influence of the climate of the arid and plateau region of the United States upon disease. A very broad view will be taken of the scope of this investigation and nothing will be neglected which may be expected to bear in any way upon the great problem for which this organization exists.

ORGANIZATION.

Director, C. L. Herrick, Ph. D.—Biological Climatolgy and Geognosy.

Vice Director, John Weinzirl, M. S., Director of Bacteriological Laboratory—Physiological Chemistry.

Edward P. Childs, B. S., Director of the Physical Laboratory—Physics and Chemistry.

George E. Coghill, A. B., M. S.—Zoology and Histology.

Frank S. Maltby, A. B., M. S., Examiner—Haematology.

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WORK OF THE LABORATORY.

It is not possible to outline the full scope of the work of this department, but a few of its lines of work may be indicated.

Bacteriology.—A complete study of the bacteria of air, water, soil, and indigenous organisms will be made. Much progress has already been made in the work upon the fauna of air and soil and facts have been discovered showing that the plateau is quite different from the eastern portions of the country in these respects. The phenomena of decomposition, fermentation, disinfection, etc., will also be investigated with a view to the possible determination of the optimum conditions for combating disease. Particular studies in the bacteria of disease, especially tuberculosis, are now making. Sputum examinations will continue to be made as occasion demands, and the laboratory has every facility for the usual pathological examinations.

Vital Statistics.—Physical examinations will be made of the students of the schools of the Territory with a view to the determination of the effects of the altitude and climate upon the impressible organs of the youth. Results of the work so far done are very suggestive.

Pathology.—With the assistance of the physicians of the Territory, it is hoped to collate a mass of statistics bearing directly upon the question of the effect of this climate upon disease.

Physiography.—That the climate is greatly influenced by physiographic conditions, such as soil, topography, geological conditions, etc., is patent at first thought. In connection with the University geological survey there will be carried on systematic work in the study of the facts referred to in their bearings on climate and disease. This work will include a report on the hydrography of the Territory.

Physics.—The electrical and photometric conditions of the plateau are of great importance in the appreciation of the effects of climate and effort will be made to determine the physical and physiological effects of sunlight, electrical phenomena, winds, etc.

Chemistry.—The chemical examination of the soils. air and physiological media will go hand in hand with the work outlined in other lines.

Haematology and Histology.—Microscopic study of the tissues will be attempted and especial attention will be given to the examination of the blood according to modern methods, as it may be expected that the changes in the blood will give the first indications of the effect of the climate.

Experimental Physiology.—Experimental control of the results by the various methods outlined above will be necessary from time to time. The co-operation of all those interested in this work is earnestly solicited.

Building and Equipment.—The fund for the erection of the building began with the gift of $10,000 from Mrs. Walter C. Hadley, which has been supplemented by contributions from other public-spirited citiens of the Territory, so that it is expected that the building will cost about $15,000. The equipment has been partly provided for by a grant from the Territorial Legislature. Opportunity will be offered to visiting scientific people to avail themselves of the appliances of the laboratory for carrying on research in the lines indicated and means of publication will be afforded.

Reprinted from The Journal of Comparative Neurology,
Vol. VIII, No. 1, 1898.

CONTRIBUTIONS FROM THE
UNIVERSITY OF NEW MEXICO.
No. 2.

PHYSIOLOGICAL COROLLARIES OF THE EQUILIBRIUM THEORY OF NERVOUS ACTION AND CONTROL.

By C. L. Herrick.

Opportunity has afforded incidentally in connection with previous articles in this journal to point out the suggestions from anatomy in favor of a theory of nervous action based on the fundamental conception that the differentia of the various forms of nervous action consist in differences in the form of resistance and the reaction thereto, or, in other words, that nerve action partakes of the nature of equilibrium. It may now be permitted to offer fresh illustrations of the application of this principle. In the first place, however, we may note that in no department of physical science is it so plain as in neurology that we are dealing wholly with dynamic elements. While it is true that in the structure of the brain we have to do with morphological details of marvelous complexity and the descriptive side of our work is concerned with the varying outlines, sizes, and combinations of cells, fibres, etc., and the still more recondite structures within the cell and their dendrites, yet it is always obvious that these morphological peculiarities are but the expressions of inner forces and their responses to others from without. Thus it may even be doubted whether such a body as a centrosome or, at any rate, a centrosphere exists as a material element. Authors have been content to interpret the "asters" as the visual evidence of differential attraction in the cytoplasm.

It is possible to go farther and admit that all the structures with which the cytologist (and so the physiologist) has to deal are the visual interpretations of dynamic processes. This is more apparent to the neurologist than to the crystallographer because the former grows accustomed to observe the close correlation between structural differences and conscious experience whose dynamic nature it is impossible to doubt. There can be no more doubt that the morphological peculiarities of nervous or other tissue are the expression of the equilibrated forces of growth and other functions than that the form and polariscopic qualities of a crystal represent molecular reactions. It is also apparent that the concept of matter in either case helps not at all in the explanation of these forces and that the attribute of materiality is to be determined on independent grounds. Not to discuss the ontological question at this time, it may simply be said that in our use of the morphological terms it is only with the reservation that they are convenient expressions to define the constant elements in our experience of dynamic forms. There are many advantages in this more direct interpretation of vital phenomena, for by the interpolation of imaginary material elements between the objective force and the subjective experience one loses sight of the constant dynamism—a dynamism which does not make necessary a fresh explanation of each new expression of force; for the existence of force may be regarded as self-evident when we recall that activity is the sole element of experience, and its varying forms are, in a sense, the algebraic expressions for interactions. The whole question of trophism is robbed of most of its difficulties if we think of structure as not a thing dissimilar from function, but consider both as different expressions of similar forces.

It would seem that especially in the sphere of embryology we should be ready for the abandonment of the fruitless search for material grounds for persistence of type. The theory of pangens is one illustration out of many of the absurdities to which a materialist construction is driven. The observed conformity to type observed in each of the thousand plants which may arise by minute subdivision of a moss, for example, shows how hopeless is the attempt to base on any specific material the capacity for heredity, no matter how eked out by the doctrine of latency. Correspondence in mode is the condition of identity implied by a dynamic theory, and the heterogeneity expressed in the forces of the body of a man may be expressed in the terms of the forces of a spermatozoan equally well. The assimilative power necessary when we assume that repeated nucleary division takes place without reduction of the chromatin is certainly dynamic and why should this dynamic determinant be limited to some material element? Does not the body preserve its integrity in spite of the flux of its materials? Why should not the actual material of the nucleoplasm be in a similar flux while retaining its form, i. e., its dynamic attributes?

From this point of view the coordination of parts through the nervous system becomes only a special instance of a coordination in the entire organism. It is true that even the unexpected wealth of fibrous ramification in the nervous end-organs revealed by the various applications of the Golgi method is still insufficient to explain the perfect co-adjustment of part with part in nutritive and trophic equilibrium—in fact, *any* conceivable completeness of nervous *continua* would leave something to be explained, for, in the last analysis, the processes are intracellular or even cytoplasmic, Even if we should grant that unsuspected imperfections in our present methods deprive us of the power of detecting the anastomoses between neurocytes in the same circuit, yet the most perfect conceivable continuity would still leave an appeal lying to protoplasmic transmission. A forthcoming paper will afford illustrations of what is here referred to. In the skin of many (probably all) amphibia and reptiles (Axolotl and *Phrynosoma*) there exists about the cells of Leydig a very complete and beautiful protoplasmic reticulum in such a way that each large cell is completely enveloped, while the meshes commingle and pass from cell to cell. This reticulum arises from certain nucleated protoblasts which are devoid of cell wall and whose naked protoplasm fills in interstices between the larger cells. This reticulum is not an artifact for it is found by the use of widely different reagents and is most complete when the fixation of the protoplasmic structure is most perfect, and in some cases of applications of chrome-osmic + platinic chloride + alcohol solutions this perfection leaves little to be desired. Ordinary hardening processes do not reveal the structure as a rule. It may be that the protoplasm is a delicate film which is thicker in certain parts than in others but the relation to the intercellular nuclei is certain. These are entirely distinct from the chromatophores. Bethe's methylene blue process reveals the farther fact that nerve fibers, which lose the sheaths after passing through the corium, end in knob-like tuberosities in proximity to these nuclei, though whether they penetrate the protoplasm or simply spread out upon it remains, from the nature of the method, uncertain. These nerve-fibers when stained with picro carmine or fuchsin, in contrast to haematoxylin nucleary stains, seem to blend with the protoplasm and it is difficult to decide which appearance is nearer the truth. Such close contiguity between a naked fiber and a naked protoblast is too vaguely different from continuity to require physiological separation, however important the distinction may appear morphologically.

Here we have an illustration of a condition, which I believe is more general than we now can demonstrate, in which a nervous end-organ is so connected with a meshwork of vast extent as to suggest a very extensive somatic influence of a nature similar to nervous reaction over vast tissue areas.

We venture to suggest that there is no such sharp distinction between nervous functioning and the intracellular processes of the ordinary non-nervous cell as our present terminology and usage suggest. It is certain that in the differentiation of function the cells of the body at large do not give up all of their heritage of nervous or nerve-like power. Students of histogenesis may have been puzzled, as the writer has, to account for the fact that a very remarkable degree of coordinated trophic power is exhibed by the embryonic body prior to the development of nerve tracts and end-organs. The phenomena of nervous deficiency in anencephalic monsters is equally inexplicaple from the standpoint of rigid limitation of coordinating power to the nervous system. In the sponges and Cœlenterata it is plain that the coordination necessary to individual existence and perpetuation of specific characters is possible with no central nervous system. There is a form of vital equilibrium so resident in the general system as to give rise to much the same phenomena of nervous unity as in the case of higher animals. It is not at all necessary to suppose that the cells of the body of higher animals have lost this power during the differentiation of the central system; it would be more probable that the central system should be superadded.

There are a number of classes of cells which seem to be, in the nature of the case, freed from all direct nervous control. The chromatophores of the Amphibia, to which the writer has devoted some study, seem in some cases not to be in a direct way associated with a definite nervous supply.[1] They are, indeed, literary migratory, though the scope and range of movement remains to be worked out. Two things may be quite positively stated; first, that these cells are to some extent independent of fixed nervous influence, and, second, that they are very really under indirect nervous control. Experiments tried in my laboratory many years ago showed that, in young cat fish, section of a branch of one of the cranial nerves destroyed the very marked adaptive power for the injured side. A fish, originally black, when placed in an aquarium with yellow bottom invariably changed to the color of the environment unless the mutilation described prevented it.

The observations of G. H. Parker on photometric changes in retinal pigment cells of *Palæmonetes* are interesting in this connection in showing that exposure to light causes actual changes in form and a segregation of the pigment of these cells. He finds that section of the nerve or severing the eye stalk from the body does not wholly prevent the reaction. This is an illustration of a reaction exceedingly resembling a true nervous response.

The embryonic tissues of all animals possess this coordinating sensitiveness and trophic interaction to a high degree. In the extreme case afforded by the blood corpuscles and lymphocytes it seems perfectly plain that there can be no direct nervous relation and yet he would be a bold physiologist who would venture to deny that there is a most subtle and powerful coordination between the stationary tissues and the free corpuscles. One may talk of chemotropism or vital susceptibility, but such terms express merely the fact that the corpuscles, like other cells, are coordinated with the rest of the body and bear both its specific and individual impress. The mysteries of serum therapy only increase our confidence in such an intimate relation.

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[1] Methylene blue seems to show connections in some instances.

It, then, may be supposed that the circuit of nervous action in any part of the body passes through a variety of smaller somatic circuits and that the spheres of the two forms of activity overlap so that the return nerve current bears the influence of this interaction. The nervous equilibrium is only a central specialized part of a vital equilibrium embracing all the activities of the body. The wandering cell, even though not in direct continuity with a nerve fiber, nevertheless may be said to act in a "nervous field" and so is not beyond the sphere of coordination, while, on the other hand, the results of changes in the extra-nervous mechanism of the body all have their effect upon the central system. In the same way we may explain the effect of the sum of organic and total or somatic stimuli upon temperament and disposition.

The processes of nutrition may be said to be common to protoplasm quite irrespective of nervous control, but the trophic influence of the latter is well authenticated and it may be assumed that no nervous action takes place without having its effect on growth. From the above it may be gathered that the ground of the mutual reaction may be sought in the fundamental similarity of the two processes, or rather the close relation between the processes of waste and repair lying at the foundation of both. It is necessary to suppose, accordingly, that the central nervous system is continually affected by the vital phenomena of the body at large as truly as the vascular system is under the control of the nervous system.

As a striking result of this effect of the somatic or extraneural processes, one may take the phenomena connected with the restoration of mutilations. When the newt's foot is amputated, under favorable circumstances the organ is quickly reproduced and the parts so restored differ in no obvious way from the old organ removed. What is the power which causes such a miraculous change? Does it take place because a simulacrum of the missing limb exists in the soul and the new body develops to correspond? With due allowance for use of terms, we reply, "yes, such a simulacrum does exist." The form of the central equilibrium has been determined by constant reactions between the member and the central system and when the member is lost the equilibrium so established is still in force and the nervous stimuli which but lately served to supply tone to the limb now operate upon the stump. Intense irritation results and the tendency is to influence growth at the point of injury.[1] This growth is under the directive control of the nerve just as we know the normal growth constantly to be. If the nerve of the limb be injured beyond repair monstrous growth results. It may be assumed that in case the leg were amputated and the nerve destroyed in the stump above, that the efforts at restoration might be abortive or result in monstrosities. It would be well to test this matter experimentally. It is believed that the application of the ideas indicated in this paper to the higher spheres of nervous activity will prove fruitful.

Another application of the same principle is found in the processes connected with the regeneration of severed nerves. It is a well authenticated fact that, in the case of section of a peripheral nerve, the nuclei of the sheath of Schwann pass to the centre of the lumen and form the protoplasmic prota of the segments of the new nerve—a process wholly unintelligible if we agree with Kölliker in regarding the sheath nuclei as derived from non-nervous connective tissue corpuscles, but not so remarkable if the abundant evidence be accepted that these nuclei are but the diverted nuclei of the cells which formed the nerve originally by proliferation and moniliform concrescesce.[1] We here have an instance where the protoplasm of the cells has become specialized and the nuclei switched out of the circuit and apparently related to the process of forming the cell wall. But, in spite of the specialization implied in the production of an organ for nervous conveyance alone, it appears that the early nature of the cells is dormant rather than lost, so that in the case of injury and the consequent degeneration of the myelin and axis cylinder, the nuclei, with the small portion of less specialized protoplasm associated, return to the embryonic state and repeat the process of neuro-proliferation, after which the new channel is organized from the center outward and the nuclei return to their parietal position. It is more than probable that a similar rejuvenescence is possible in the case of other tissues also.

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[1] The assumption that irritation may produce proliferation is supported by the pathological karyokinesis in case of local irritation; see also processes connected with development of spermatozoids, etc.

We have many instances of the same kind of differentiation within the cell. Take as an illustration the formation of glands in the skin of the frog, where a follicle is formed and then the several component cells are fused, the outlines being lost, and only the small nuclei which remain in the thin parietal layer of less altered protoplasm remain to indicate that the gland is really polycellular. It would be interesting in this case to institute experiments on the possibility of rejuvenescence of such cells.

In the application of the neural equilibrium theory to problems of heredity it would seem that there is a large and profitable field. Without attempting details in this direction, it may be pointed out that this point of approach renders unnecessary a vast deal of the most profitless theorizing in reference to heredity. If the neural and somatic forms of reaction are not absolutely unlike, but on the contrary are parts of a common vital type of energy (or rather force) and if it be admitted that the processes of nutrition may be and are influenced by the neural equilibrium, it follows that the germ is also situated in the field of these equilibrated forces and its composition, i. e. its own force formula, would be the resultant of the reaction of the existing (ontogenetic) formula as modifying the earlier (phylogenetic) force formula. Instead, then, of searching for "ids," "bioplasts," gemmules," or the like we may feel assured that, in a much more complete and integrated form, the entire life of the organism will have its effect on the germ. This confidence will not cause us to pay less attention to the structural appearance of the cell and, in particular, the germ cells, but will prevent loss of valuable effort in the invention of sterile theories and prepare the way for a dynamic interpretation of these phenomena.

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[1] The nuclei of the ending of the motor nerve on the muscle offer interesting collateral evidence. See the article by Dr. Huber in the last number of this Journal

It may be noted in this connection that S. Ramon y Cajal has apparently suggested, by implicatian at least, some of the grounds for the equilibrium theory in his suggestive article in the *Archiv f. Anatomie u. Physiologie,* 1895. He says: "Die Phänomen der vorerwähnten lawinenartigen Leitung, sowie die geringe Zahl der sensorischen Elemente (Zapfen der Fovea centralis, akustische Zellen u. s. w.) welche alle die zahlreichen Eindrücke, für welche unsere Sinne empfänglich sind, aufnehmen müssen, zwingen zu der Annahme dass jede Sinneszelle, sowie jede subordinirte Gruppe von Pyramidenzellen des Gehirns successiv an der Production verschiedener Bilder sich betheiligen. Vom anatomisch-physiologishen Standpunkt aus, wird eine Wahrnehmung von einanderen, zu derselben Empfindungsquantität gehörigen, durch die Zahl und die betreffende Lage der corticalen in Erregung gesetzten Pyramidengruppen unterscheiden." It would seem to be evident from the above that not only the exact impression to be perceived is not produced by the organ of sense (since it would then be divided into a large number of parts in being transferred to the larger number of pyramid cells) but also that inasmuch as the same cells may be participants in different percepts the physiological basis for the latter must be the particular formula of these permutations in a given case and thus a simple impression must be of the nature of an equilibrium constructed from the interactions of the cells implicated.

In conclusion, it may be noticed that the ideas advocated above have a very interesting bearing on the problem of the origin of variation. The theory of the competition of parts has taken strong hold of modern biology because it is becoming more and more evident that the sphere of natural selection must be greatly restricted and some appeal must be made to forces residing within the organism. Even Weismann in his extreme advocacy of natural selection has been forced to yield a large place to the effects of inner coordinations. We suggest that the nature of these coordinations is rendered much more intelligible by conceiving of all these vital-nutritive processes as equilibrated forces. If for any reason, a given part or tissue of the body is in the least exaggerated, its part in this complex coordination is increased and, accordingly, its reflex influence on the organism as a whole, or its nerve centers, will be increased and its quantum of the centrifugal currents will also be increased, so that the tendency will manifestly be for the newly created variation to go on increasing indefinitely until checked. The next generation will inherit this tendency and we should find that, in the absence of restraint, there would be the constant likelihood of the appearances of strange monstrosities with apparently unaccountable exaggerations of horn or spine. It requires very little familiarity with paleontology to discover that its records abound with cases in which no possible serviceability would account for the absurd burlesques which have been produced and only the comparative familiarity of existing types blinds us to the same fact. While not denying that there is a large element of useful adaptation in all cases (otherwise they would never have been preserved), yet it will be admitted that a very considerable proportion of the peculiarities and often the deeper seated characters have no such explanation. We should not be surprised at this, for it is apparent that the slightest variation not directly hurtful will tend to perpetuate itself. It may be said that all unnecessary parts will be eliminated as sapping the nutrition of the body at large. This is an abuse of a teleological principle for it is not to be assumed that the body is reasoning from present causes to distant effects. If an eye ceases to be used it is atrophied, not because it is no longer useful and is therefore a cumberer of the ground, but because, the function having ceased, it is actually participating less in the equilibrium than formerly and also less than other organs. But a newly formly wart on the skin may be absolutely useless, yet, like a corn, it may be the seat of irritative processes which stimulate nutrition. It is then not the ideal utility but the degree of participation in the vital equilibrium which is the primary determinant. It is necessary to seek no farther for the source of variation and it is not surprising, when we consider the infinite possibilities for the increased vital activity of one group of cells over another that natural mimicry has found at hand all the necessary variations upon which it is to work, though we must not hope to find in their number and variety the complete explanations of the imitations produced.

University of New Mexico, Feb. 20th, 1898.

CONTRIBUTIONS FROM THE

UNIVERSITY OF NEW MEXICO.

No. 3.

THE SOMATIC EQUILIBRIUM AND THE NERVE ENDINGS IN THE SKIN.

By C. L. Herrick and G. E. Coghill.

PART ONE.

With Plates V—IX.

Few problems have proven more attractive or more illusory than the general question as to the nature of the nerve termini in the membranes, for it would seem that our concepts of the histogenesis and so of the real nature of the sense organs depend very largely upon the conclusion at which we arrive as to the relation between the various types of sensory epithelium. The senior writer suggested, in a series of papers on the brain of the lower vertebrates, reasons for believing that the first sense to come into the field of consciousness was that of smell, and a little later Edinger emphasized the same idea by his investigations of the olfactory tracts of the reptile brain. It may now be taken as fairly proven that, if the seat of consciousness is in the cerebrum, smell was the first of the special senses to find its way to recognition by it. It would then be natural that we should expect the peripheral organs of olfaction to retain a primitive character and so to afford us a clue to the early state of such organs. Then too the development of the accessory or non-nervous organs of sense has here hardly made any progress even in those most highly differentiated cases in which Jacobson's organ has assumed great proportions.

From studies of the development of the olfactory organs in reptiles, as reported briefly in earlier numbers of this Journal, the writer has been abundantly convinced of the truth of Beard's statement that the olfactory prota arise from the skin and, by a proliferation, extend to the brain, there to enter into communication in the glomerules with the processes of the mitral cells of the tuber.

As studied in the embryos of snakes the process is as follows: The first indication of the change of the ordinary to the sensory epithelium is seen in the thickening of a portion of the superficial layer from the morphological front of the head (the region of the future infundibular recess) in relatively broad bands, one on either side of the head. As the head flexures increase, these areas are carried ventrad and come to occupy the roof of the mouth and adjacent parts of the buccal cavity. The development of the taste buds from this epithelium we have not traced in these subjects, though there is no reason to doubt that they are formed from this proton, as it is easy to see that the mucous part of the hypophysis is. At the time the first olfactory rudiments appear, the curvature is such that the hemispheres are protuberant in front and so come nearly in contact with the prota of the olfactory in the two bands of germinative epithelium above mentioned. Still there is no difficulty in seeing that the original proliferations take place in the skin and that the constant proliferation by division of the earlier cells spins the nerve fiber from the original source to the point where the tuber subsequently arises. In fact, the tuber, which has frequently been compared to the ganglion of origin of a cranial nerve, does not seem to afford origin for any centrifugal fibers whatever. In preparations by the silver method it is easy to see that the neurite of the moniliform chain of the olfactory nerve comes into relations in the glomerules with dendrites of the mitral cells. Though a considerable wealth of detail has been secured by study of Golgi preparations during the last few years, nothing has been brought to light to invalidate our original view.

For a long time during the development of the brain an obvious ganglionic mass lies below the skin at the base of the point of origin of the olfactory. The gradual elaboration of the cavities of the nares only serves to redistribute the prota without materially disturbing the simplicity of the arrangement.

In a wide range of types it has been possible to make out the adult conditions which have often been correctly described. Merkel in his classical work gives a figure of sensory endings from a cirrus of Amphioxus that compares in every detail with the specific cells of the olfactory epithelium of a reptile or amphibian. (Plate III, figure 10.) Few if any of those who have studied the development of the olfactory will venture to deny that the "Stiftzelle" at the peripheral end of the olfactory nerve is a member of the nervous series having the same origin, though it is doubless conceivable that, through some strange fatality, every observer has failed to notice the intrusion of a foreign element at some stage of the process. (Fig. 31.) If, however, we take for granted that the fiber is continuous, we claim that there is an equal necessity for admitting the same for other clusters of nerve endings on the surface of the body.

Although there was for a long time considerable disagreement as to the actual connections of the olfactory nerve fibers, and the classical studies of Kölliker, Klein and Piana left the matter open, it seems as though the later studies of Ehrlich, Arnstein, Cajal, Gehucten, Retzius, Brunn and Lenhossèk, who employed the silver and methylene blue methods, were sufficient to prove conclusively that the olfactory epithelium possesses rod cells whose proximal end is an actual continuity with the fiber of an olfactory nerve filament. The writer has frequently verified this in specimens of Amphibia double stained with hæmatoxylin and picrocarmine in which very unambiguous views can be secured. A few figures from these preparations were published by Mr. Bawden, then a student in the writer's laboratory (Jour. Comp. Neurol. IV). Our studies in the development of the olfactory nerve show that the proton of the nerve is formed in or under the epithelium of the nasal area and that the nerve grows by moniliform concrescence of cells which arise by mitosis from this proton. From this stand-point, then, it would be expected that the neurocytes of origin would be found in the epithelium. In all essential respects the relations in Jacobson's organ are the same as in the true nasal olfactory epithelium. The accompanying figure (Plate V, Fig. 10) from an article by Lenhossèk (Anatom. Anzeiger, VII, 19-20.) illustuates these conditions and also the fact that other nerve fibers, apparently from the trigeminus, terminate in free arborizations between the epithelium cells. A very large following of the new school are prepared to claim that the conditions in the olfactory epithelium are peculiar to it alone and it is even attempted to correlate this with a supposed fundamental difference in origin and structure of the olfactory from all other nerves of the body. But we are able to show that in the epidermal sense buds of the tree frog and other amphibia the same continuity of nerve fiber and cell can be determined.

It has not been an altogether unnatural result of the remarkable complications of nervous structure revealed by the so-called specific methods that the results obtained by the old histological methods have been discredited and it has required some year's experience to teach us the danger of too explicit reliance on the former. Perhaps the greatest of these sources of ambiguity arises simply from the fact that has been regarded as the chief excellence of these methods, namely that the selection is so perfect that other tissues than those selected not shown at all or, even if the after-staining of sections succeeds, the conditions of impregnation are so unlike that the tracing of connections or definite relations is difficult or impossible. The absolutely contrary results of Dogiel and Cajal in the matter of the anastomoses in the retina illustrate the difficulty that exists even where the methods used are similar. The results of our own studies are rather to confirm many of the old observations and to show that there are two distinct classes of dermal endings. Of these the olfactory illustrates one and the most primitive one. In this case we have to deal with the remnants of nervous aggregates which were originally formed in or near the outer layer and in the phylogenetic development have not been diverted to a deeper level as is true in so many other instances.

In our laboratory in 1891 we made out the fact that in the oral region of the earth-worm there are cells in the skin which have a nervous nature and whose processes pass entad to the central system. Owing to a delay in the other aspects of the research the observation was not made public till the brilliant work of Gehuchten had afforded proof of the same thing, but the suggestion was of course inevitable that we have in the lower forms a permanent retention of cells in the skin which in higher types have tended to become concentrated in the central organs. What more natural, however, than that this concentration should be incomplete, especially where these cells have have acquired a specific sensory function. When the application of the Golgi and methylene blue methods revealed the fact that there is a most complicated set of free endings in the skin and that in many cases where a nervous continuity had been described there is simply a secondary apposition of a dendrite to preexisting non-nervous cells it was inevitable that the existence of cellular nerve endings should be discredited entirely. It is true that the greater part of the sensory prota are collected in the spinal and cranial ganglia and seem to proliferate thence to the periphery; but in various regions, particularly of the head, these ganglia never concentrate in a neural ridge but retain their original place in the neighborhood of pharyngeal clefts and the like and the possibility must be allowed that other cell-clusters elsewhere may have done the same. However, there is another possibility to be considered; namely, that the terminal portion of the peripherally proliferating nerve fiber may under certain circumstances develop a specialized terminal dendrite. When the nerve is in process of developing the subdivision of the distal member is repeated progressively until the definite terminus is reached and then the extreme element is charged with the function of adapting itself to the conditions there prevailing. In the case of the motor ending, even the careful researches of Huber and De Witt do not finally dispose of the question as to the origin of the end-structures. We may interpret them as follows: when the fiber reaches the muscle its terminal element, together with the nucleus, applies itself to the surface of the latter and prior to the formation of the muscle-sheath, proliferation goes on in a less regular way than during the development of the nerve itself, in this way is formed the "sole," which would, accordingly, be of a nervous nature. On the other hand, it is possible that the nerve on entering the muscle comes in contact with a nucleus of the muscle which, under the stimulus afforded, begins to proliferate and the protoplasm of the cells so formed assumes an intermediary character and spreads out upon the surface of the muscular band as a means of applying the stimulation. To us the first is in the absence of direct evidence the more probable solution.

Observations are at hand which tend to show that extensive nervous proliferation takes place below the corium of the skin at an early stage. In section of the skin of Amphibia these proliferating cells can be seen and this is probably the origin of the ganglion plexus of the skin. (Figs. 3, 5 and 6, Plate V.)

To pass then to the nerve endings in the skin, we may first note the isolated sensory cells. These may be seen in suitably prepared sections of the head in the tree frog and other Anura and also in the neighborhood of the eye in the axolotl and other tailed Amphibia. In the tree frog, where they most numerous, these cells are grouped in threes and fours in close clustres lying in a special cavity passing through the entire thickness of the epithelial layer. The terminal segment is a slender nucleated cell, the nucleus being very narrow. The peripheral part of the cell is a narrow rod which at the periphery bears a few rigid bristles. Entally from the nucleus the cell walls are very delicate but obvious and the nerve fiber within is easily distinguishable in the doubly stained specimens. The fiber is easily followed to the corium layer and in many cases through it. It seems too that more than one nucleus can be seen in the course of the fiber before the passage through the corium. The skin is at this point very thick and the presence of large glands serves to separate the corium from the epithelial layer, so that the course of these fibers is readily followed for a long distance. In the case of certain teased preparations it was possible to isolate these fibers and study them with oil immersions and there can be no doubt as to the relations here described. So far as could be told, these fibers do not connect with the subepithelial plexus as do the fibers of the free arborizations to be described later. (Figs. 2, 12, 13, 14.) The terminal segment seems to be entirely homologous with the segments of the nerve and its peripheral portion is perhaps simply a modified dendrite.

The endings above described must not be confused with the sense buds found elsewhere in the skin. In the latter there is a well-developed accessory apparatus in the form of the well-known beaker or "Stutz" cells, here there is simply a cavity or tube in the midst of unmodified epithelium cells. Yet it is not to be assumed without better evidence than is now at command that these two classes are of entirely distinct nature and origin. In the first place it is scarcely to be credited that two sets of sensory organs derived from the same proton and so similar in function as are the organs of smell and taste should be of an absolutely different type, and what may be said of the taste buds applies *mutatis mutandis* to the sensory buds of the skin.

The contrast between the results of different methods is nowhere better illustrated than in the different conclusions reached by Fusari and Panasci on the one hand (Arch. italiennes de Biol. XIV, p. 240) and those of Arnstein (Archiv f. mikroskop. Anat. XXXXI, 2). The former authors worked with the chrome-silver method and describe a direct communication of the nerve fiber with the axial (rod) cells of the taste buds. (This we are able to substantiate from personal observation.) Arnstein, on the other hand, denies such connection most emphatically and claims that teased preparations with methylene blue show with all possible clearness that there is no such connection, but instead that the varicose nerve fibers form a felting of fibers around the axial and outer cells of the bud and end free in the pore. Arnstein finds quite similar nerve endings in the filiform papillæ. He does not find forked cells, but inclines to the view that such cells result from the separation of the true nerve fiber from the peripheral end of the cell to which it is attached. The appearance of continuity between the cell and the nerve fiber is said to be illusory and is explained as due to the blackening of the cell as well as the fiber. Ehrlich (Deutsch. med. Wochenschrift, 1886, 4) described intensely colored cells in the mucous membrane of the olfactory region which pass without interruption into a nerve fiber, but these cases Arnstein also dismisses as illusory. Dr. Niemack has also reached similar conclusions by the use of different material (Anat. Heften, Merkel und Bonnet, Anat. Anzeiger, VIII, p. 20.)

Inasmuch as the epithelial layers of the mouth and tongue are morphologically only portions of the skin, it is necessary to examine these regions for light on the nerve endings as they may be modified under the special conditions here existing. In the frog, which has been the subject of the most elaborate invstigation, the sense of taste cannot be at all highly developed, for the animal is accustomed to swallow its food, chiefly horny coated insects, without mastication; and experiments (Bethe) prove a very sluggish response to chemical irritants. In the tongue of the frog, as well as in the palate, there are numerous scattered specific sense organs, those of the tongue being flat end-plates, while those of the palate are protuberant sensory papillae. Athough these organs were described by Leydig in 1858 they have frequently been the objects of special study since then and even now authors are not wholly in agreement as to the details of the structure. The cellular elements in these sense organs consist of the cylinder of flask cells forming the protection for the sensory rod cells, a subordinate variety of which has been termed forked cells by reason of the divided peripheral projection. Alate, or winged cells, around the cup or flask have also been noticed by some authors. Bethe, who has recently studied these buds by means of the modification of the methylene blue method which bears his name, finds two sorts of nervous termini in them: first, free termini lying between the cylinder cells and reaching the surface, second termini with bulb-like expansions on various cells. (Fig. 8.) One type of such endings is three-lobed and such endings are affixed to the sides of the cylinder cells; the other variety has simple circular end-plates and these endings are found on the rod cells, fork-cells and possibly also on cylinder cells. In no case did Bethe succeed in finding actual continuity between the rod-cells and the nerve. He in fact seems to find greater intimacy of connection between the cylinder cells, which are not supposed to have a nervous function, than with the rod-cells and in no case is there more than a contact with the cell wall. He explains the continuity detected by Arnstein and others as the result of faulty observation and imperfect methods. In the ordinary pavement epithelium of the palate Bethe finds termini on gland cells and ciliated cells, as well as deeper elements. It should be noted that the finding of the three-lobed end-plates on the cylinder cells was not a uniform occurrence but rather exceptional and the suggestion is near that this is the result of an accidental state of the fibers and not a natural or permanent organ.

Our own studies of the gustatory epithelium of the axolotle are in accord with the results of Bethe upon the frog so far as the diffuse endings are concerned, though the methylene blue does not give adequate insight into the connections between fibers and cells. The taste buds, on the other hand, afford similar results to those obtained from the sensory buds of the skin. The source of many of the erroneous conclusions reached is, as mentioned beyond, the fact that in successful methylene blue preparations it often happens that fibrous elements stain when the cells of origin for the same fibers do not.

Diffuse Peripheral Connections.—Various early writers have reported the existence of a dense net-work or felting of nervous material among the epithelial and even the corneum cells of the skin. This structure was first made out by the use of gold chloride and there was always left open the possibility that the appearance was due to the disposition of metallic salts in the interstices between the cells. Dogiel in his paper on the nerve endings of the genitalia figures a very extensive mesh-work of this kind with here and there a free knob-like termination and he traces the lower part of the reticulum to a direct communication with a set of nerve fibers passing perpendicular to the skin. (Fig. 1.) Strong in his paper on the cranial nerves of the frog figures a similarly minute meshwork which is revealed in this case by the use of the Golgi method. In all of the above cases there is the element of uncertainty growing out of the fact that the methods are impregnation rather than staining processes and are histologically uncertain. It would then be eminently desirable to supplement the evidence from these sources by other means. In the study of the skin of the Amphibia it is easily noted that there exists at the base or ental aspect of the layer of Malpighi a layer or stratum which is in a peculiarly nascent state. These cells are devoid of the thick and rigid walls chatacteristic of the superficial cells and are protoblasts rather than complete cells. In this layer we may find, at all stages, the evidences of mitotic division. In fact there is a permanent proliferating zone in this region. Comparison of this stratum with that of higher vertebrates shows that the latter form no exception, though it is not always easy to detect the protoblastic elements. A single theoretical consideration is sufficient to convince one that this is what should be expected, for it is of course recognized that every type of vertebrate has some provision for the constant or occasional removal of the skin. In some cases the process of removal of the corneum is intermittent, while in others it is gradual. In either case it is obvious that there must be a proton of undifferentiated material—of cells that have not passed beyond the plastic stage. In those parts of the skin where there is little differentiation between the various layers the difference between the corneum and deeper cells is not readily detected in preparations by the usual processes, but in the thicker portions where the so-called Leydig cells appear the basal protoblasts are crowded into the interspaces and pried apart. One effect of this process has been to stretch the connecting protoplasm into an excessively thin layer or film enveloping the Leydig cell either completely or as a coarse mesh-work of naked protoplasm. In all the preparations we have seen, even those in which the preservation has been as perfect as possible, without the least evidence of shrinkage, the appearance is that of a broad reticulum arising in the intercallary or basal protoblasts and enveloping the cell in such a way as to wrap it completely in the products of the adjacent protoblasts. The most perfect process of preservation for such structures is a combination of chrom-acetic and platinic chloride diluted in alcohol. The use of Merkel's solution also gave very good results, while the various osmic acid solutions invariably produce too great shrinkage of some parts, especially of the reticulum. In the first mentioned solution it appears that the natural tendencies of the alcohol and the chromic acid counteract each other while the fixing action of the platinic chloride is in no way interfered with. The avidity to all the usual stains after this treatment is also very great, while in the osmic preparations there is not only general diminution of the receptivity, but, what is worse, the effect is not uniform even in the same class of tissue in the same preparation. In properly prepared sections the reticular structure of the protoplasm of the Leydig cells is most beautful, but when osmic solutions are used the contents of the vesicles is blackened and the result is a granular appearance instead. The pericellular mesh-work is stained red by picrocarmine, as is all protoplasmic matter, while the nuclei are all selected by the hæmatoxylin. Nerve fibers stain red but their nuclei are purple. The nerve supply is abundant and the fibers can be traced without difficulty through the corium layer in all preparations. The sheaths seem to cease after passing the corium and the subsequent course is less easy to make out. In a considerale number of cases it has been possible to trace such fibers with all desirable clearness to actual connection with the bases of the lower protoblasts above mentioned. The fiber is red, as is the protoplasm, so that it remains possible that the exact nature of the union is not obvious, yet from the fact that two masses of naked protoplasm thus come in contact, the range for possible modes of union cannot be extensive. In any case the most careful examination under immersion lenses of well-stained specimens does not reveal any form of intermedation between the fiber and the protoplasm of the cell. Nor is this relation limited to the lowest layer of protoblasts alone, for it is possible to trace fibers to some of the higher members as well. The attempt has repeatedly been been made to count the number of fibers entering the given area and then to compare this number with the number of protoblasts in the same area, with the result that the fibers proved more numerous than the cells in the lower series, thus offering independent evidence to the effect that these fibers are destined to more than the single basal row of protoblasts.

The pericellular net-work has been described by a number of the earlier observers, but in each case the real nature of the structure has not been detected. Paulicki and Pfitzner both regarded it as a mesh-like thickening of the cell wall. The latter thinks these "ribs" serve for the point of attachment of the "intercellular bridges." Part of Paulicki's description is given in füll. "An einigen Leydig'schen Zellen wurde ich auf kleine kreisförmige, länzende, dunkelconturirte Figuren aufmerksam, die in ziemlich regelmässigen Abständen von einander entfernt

der äusseren Fläche der zellmembran aufsassen. Es stellte sich nun alsbald heraus, das dieser Befund bei allen Leidig'schen Zellen ein ganz constanter ist. Ueber die Deutung dieser Gebilde erhielt ich durch Zellen, wie deren mehrere abgebildet sind, Aufschuss. Hier fand sich ein doupltconturirtes Gitterwerk, welches uber die Protoplasmakörner hinwegging. Die Balken des Gitterwerks theilten sich öfters gabelformig und waren bald dünner, bald dicker. Es ist nun anzunehmen, dass das Gitterwerk hervorgebracht wird durch rippenartige, partielle Verdickungen der Zellenmembran, und dass bei solchen Zellen, wo ein derartiges Gitterwerk zu sehen ist, der Schnitt die Zelle tangential getroffen hat, während bei den Zellen, die dieses Gitterwerk nicht zeigen, die dagegen in der Zellmembran von Strcek zu Streck kleine, glänzenden Ringe besitzen, der Schnitt mitten durch die Zelle gegangen ist. Die kleinen Kreise, die der Zellenmenbran aufsitzen, stellen die Querschnitte der rippenartigen Verdickungen der Membran dar. Die rippenartigen Verdickungen der Zellenmembran Zeigen sich durchs ämmtliche Farbemittel ebenso gefarbt, wie das Protoplasma, wesshalb sie leicht ubersehen werden könen." The author also notices that these bands are sometimes sharply stained by fuchsin, a fact that, in connection with the above, might well have suggested that these supposed ridges on the cell wall have a nature more in common with that of protoplasm. Still more suggestive was the additional observation that these ridges are not limited to any single cell, but often pass to neighboring cells without interruption. He says "Ich sah, dass die Balken von einer Leydig'scher Zelle continuirlich zusammenhingen mit den Balken benachbarter Leydig'scher Zellen, dass ein zusammenhängendes Balkenwerk sich uber mehere Leydig'sche Zellen ausdehnte. Ausserdam sah ich aber auch, dass ganz ähnlich gestaltete Balken sich auf die benachbarten Epithelzellen fortsetzen."

Our observations leave no doubt that this meshwork is not only of a protoplasmic nature but that the meshes are connected with the nuclei of the basal and intercallary series. (Figs. 17-20). It is easy to trace the meshes into communication with the proplasm surrounding these protoblasts. It is more difficult, except in the case of perfectly preserved material, to follow the nerve fibers to the bases of the cells of the higher series, i. e., those about the sides and ectad of the Leydig cells. In good methylene blue specimens stained *intra vitam* (Figs. 21-23), the fibers can be traced for a considerable distance into the epithelial layer among the intercallary nuclei, but it is only in specimens stained with picrocarmine and hæmatoxylin that the actual connection with the cells can be made out. Even here the question (always left wholly undecided by the methylene blue method) as to the nature of the association is not entirely deprived of its ambiguity. When a fiber of naked nerve-plasm unites with a protoblast of naked cytoplasm, who shall say whether the connection is primary or secondary in the absence of the most intimate embryological evidence or regeneration experiments?

An important question in this connection is that as to the source of the nerve fibers. Do they arise in the prota of the skin or do they enter the skin from out-growths of the spinal ganglia? It would seem natural to conclude that the latter is the case, and yet it is not a little puzzling to see that nearly every cell in this series has its fiber. Then, too, the fact has been repeatedly observed that the protoblasts are continually dividing, even in rather large specimens of axolotl. (Fig. 20). It must be left to careful embryological studies to decide whether there are cells of origin in the skin for centripetal nerves or not. Another question must await either an embryological or pathological solution, and that is the detection of centrifugal fibers among those entering the skin. Such non-medullated fibers doubtless occur and we may think of the plexus immediately below the epithelium is the probable site.

We have sought to verify the results above described by the application of the methylene blue *intra vitam* method as well as the tissue methods used by Dogiel, Bethe and Huber. Making all due allowance for the ambiguity of these methods, it seems that the results are in harmony with those above mentioned. It is not difficult to secure impregnations in which every fiber is stained throughout its course through the corium, but to our surprise they seemed to stop short in the vast majority of cases in the zone at the base of the layer of protoblasts, while only in comparatively few cases did we trace connections like those described by Bethe with cells of higher layers. In the chromatophore zone just ectad of the corium in many parts of the skin it was possible to trace fibers horizontally long distances and in some cases supposed communications with the chromatophores or similar bodies were noted. (Fig. 21). In most cases these cells were nearly destitute of pigment and pass by all gradations into undoubted ganglion cells.

In this connection mention should be made of the remarkable results reported by Dr. W. Pfitzner.[1] This writer claims to trace the fibers after their passage through the corium into the substance of the cells and to follow them to small knob-like endings free in the protoplasm of the cells. More than this, he traces to each cell, not only of the deeper layers but also of the stratum corneum, two independent fibers from quite distinct sources and founds upon this observation an elaborate hypothesis, which unfortunately is deprived of all standing-room by the evidence now at hand. Mr. Massie has pointed out that there is a stage in the young amphibian skin when a curious skein of a material staining deeply with some reagents is found in the cells. The senior writer, who made the preparations used by Mr. Massie, can vouch for the accuracy of this observation. It is not unlikely that the suggestion is waranted that this skein is an embryonic and transitory element in the development of gland cells, as it is not found in all the cells but in a certain class dispersed among narrower cells having a different reaction. This skein (Fig. 4) is as certainly intracellular as the nerve fibers are extracellular in their course. Figures almost identical with those published by Pfitzner as the results of his observation can be secured by his methods, especially if the sections are taken a little oblique (Fig. 24.) The process serves to stain very distinctly the part of the nerve that is medullated, i. e. that part extending through the corium, but not that part which extends above the corium among the cells. Such fibers can be seen, it is true, but they are so different in appearance from the medullated part of these fibers that we are forced to conclude that what Dr. Pfitzner really saw is the intracellular skein of which mention has been made. It is a most natural mistake in the absence of more reliable methods and especially as the methylene blue process was not at his disposal. The finding of two nerve termini in each cell is apparently to be explained as a result of the fact that the base of the skein is hidden, as we found it to be in oblique or thick sections, so that the appearance figured by Pfitzner frequently recurs and if one had a preconception in favor of the the nervous structure of the element one might easily construe it as he has done. After the above we may be released from the obligation to consider the extensive and interesting theories based upon the supposed intracellular endings.

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[1] Nervenengungen im Epithel. *Morphol. Jahrbuch*, 1882, p. 726.

Transitional Cells. In certain regions of the skin the epithelium layer is greatly thickened and the Leydig cells are rereduced in number or carried to a higher (ectal) level. In such portions of the skin, as on the dorsal region, an interesting modification of the structure above described is found. Here the lower series of cells is elongated in a direction perpendicular to the surface forming a sort of palisade type of cells. A definite wall is often apparent in the lower portion proximad of the nucleus, while the peripheral part seems to fray out into a representative of the pericellular mesh-work. Where the Leydig cells are present there is every reason to believe that these cells participate in the formation of such of a pericellular network as has been described above but somewhat modified by the changed conditions. In a large number of cases we have observed a nerve fiber after passing through the corium seeking the base of these cells and making an intimate connection with one of them. Here the opportunity to observe the union is much better than the other case and the connection is perfect. In a certain sense these cells are intermediate between the rod cells and those that supply the pericellular meshwork. (Fig. 25.)

Dogiel[1] has shown that in the eyelids of man, for example, where the number and complexity of the sense organs is extreme, the terminal bodies consist of a covering of several connective tissue layers separated by zones of flat epithelial cells enclosing the nerve net. The nerve net is described as lying free in the interior of the bulb, though a faintly stained material was noticed and regarded as coagulated lymph which may represent cellular elements not competent to be revealed by the methylene blue method. (Fig. 9.) The nerve fiber loses its sheath before it penetrates the bulb and at once divides into spirals or coils forming a loose mesh-work. Aside from these specific cells, there are extensive arborizations and nets of fibers diffusely scattered in the epithelium at large.

In some respects the fullest description of the highly differentiated sense organs of the skin of the genitalia has been given by Dogiel and his results are pertinent to our purpose, inasmuch as he finds that all the end-organs reduce to one type—a terminal recticulum. The so-called genital sense organs and the Krause's and Meissner's bodies all prove to consist of a capsule containing a reticulum of varicose fibers and, especially in the case of the genital corpuscles, those of the same order are frequently connected by lateral anastomoses. In addition to these special organs, Dogiel traces medullated fibers into an inter-cellular reticulum within the epithelium so fine and dense as to come apparently into relations with all the cells of the deeper parts of this layer. Occasionally a branch turns peripherally and ends in a knob at some distance below the surface. We seem, then, to have evidence that the typical form of nerve ending is a close pericellular network, though Dogiel's method is not such as to allow of determining the relation of the fibers to the cells. (Fig. 1.)

The most remarkable suggestion respecting the homologies of the sense organs of the skin in amphibians is that of Maurer who thinks that the hair of vertebrates can be traced back phylogenetically to these sense organs. Leydig in Biolog. Centralblatt, XIII, scouts this idea and derives the hair from the so-called "Perlorgan" of certain fishes. The resemblance and affinity of the sense organs is rather with the auditory apparatus, as shown by Ayers and others.

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[1] A. S. DOGIEL. Die Nervenendigungen i. Lidrande, etc. Archiv f. Mik. Anatomie, XLIV, 1, 1894.

The Sense Buds. It is interesting to observe the wide differences of opinion of competent observers as to the endings in the end buds. Lenhossèk (Anat. Anzeiger, VIII, 4) denies absolutely Fusari and Panisci's statement that the proximal extremity of the sensory cells in the taste bud passes directly into a nerve fiber and states that the nerves always end free in the bud, or rather form a meshwork surrounding it, thus constituting a peri-gemmal reticulum. Nerve fibers pass in a horizontal course below the epithelium and give off collaterals from time to time which form a felting of free fibers among the general epithelium cells. Essentially similar conditions prevail in the sense buds of the mouth of fishes and the author concludes that the rod cells are to be considered as short apolar nerve-cells and that the class of nerve endings found in the earth-worm is found in vertebrates only in the olfactory organ. (Figs. 15 and 16.) Retzius takes the same view, but finds that the nerve fibers are not perigemmal but intragemmal, thus illustrating the difficulties growing out of a reliance on the Golgi and methylene blue methods alone.

A. Geberg in a brief article in the Anat. Anzeiger, VIII, 1, claims to be able to demonstrate the endings of the auditory nerve in the cochlea by the methylene method, but, inasmuch as the tissues were not stained, it seems that his conclusion, that the fibers attach themselves to the hair cells without communicating with the latter, must be considered as non-conclusive.

Having reinvestigated the nerve endings in the sensory buds of the skin of the axolotl with material leaving little to be desired as to the fixation and hardening, and which had been double stained successfully, we are able to assert with great confidence that, in this case, there is a special cellular nerve terminus having a direct basal connection with a nerve fiber. The nucleus of these cells (which cannot be termed appropriately rod cells or "Stiftzelle") is narrower and more deeply stained than the supporting cells and occupies the entire width of the cell. The peripheral part of these cells has not been correctly described as yet. In reality it consists of a projection of the cell walls to form a narrow tube. These walls are delicate and very thin but easily seen because of the contrast with the protoplasmic fiber contained in it. The latter structure is delicate but stains a deep red with the picrocarmine, while the walls are not stained by that reagent. (Figs. 26-30.) This axial fiber differs not at all from that seen in the clusters found in the scattered sense organs on the head of the tree frog and the frog. (Fig. 32.) The proximal portion of the cell is not as easy to trace, for the corium and often the chromatophores obscure the connections to a degree. Yet it now and then happens that the direct communication with a nerve fiber rising through the corium can be made out. Of course it may be insisted that this connection is only a secondary one, but nothing but evidence from embryology or degeneration experiments will substantiate or refute the claim. So far as the evidence now goes, the scattered cells above mentioned and those in the buds stand or fall together, and for the former the evidence of direct continuity between cell and nerve is unimpeachable.

The Plexus Beneath the Corium.—In portions of the skin stained *intra vitam* by the methylene blue method and examined at once in glycerine very perfect views of the marvelously elaborate plexus beneath the corium can be gained. The fibers are of two sorts, the larger being connected with the fibers from the nerve bundles from the central system, while a part at least of the fibers of smaller calibre have a local origin in certain ganglion cells of this region. These cells were first detected in preparations double-stained with hæmatoxylin and picrocarmine and were seen in section in a plane parallel to the surface. In the methylene blue preparations they are very conspicuous and surprisingly numerous. The nuclei are large, while the protoplasm of the cell does not stain or only slightly with the blue. It is an interesting and most instructive fact that the cell body remains transparent, while its own neurité or axis cylinder process is mostly intensely stained through its entire length. The hiatus between the fiber and its cell is slight but sufficient to cast a doubt on the fact of communication were the conditions not absolutely favorable. With a high power it is possible to see the sheath and the faintly tinged protoplasm so that no doubt is in this case possible.

It may be noted also that other methods seem to show that it is entirely possible for the protoplasm of a cell to react differently from that of the axis cylinder derived from it. Thus may be explained many of the ambiguous and conflicting results of the applications of the methylene blue process. Fig. 33 illustrates the appearance of a section stained with hæmatoxylin and picrocarmine, while Fig. 23 is from a methylene blue preparation. Figs. 33-37 are from surface views of the plexus, showing the ganglion cells. Figs. 38 and 39 are from the same region, showing connections with vessels and chromatophores (Fig. 3.)

It will be seen that the fibers of this plexus below the corium are of two sorts. The fine fibers arise, in part at least, in the local ganglion cells and can be traced to the nerve bundles, which they enter and then mingle with the fibers of the larger sort. In the perpendicular sections it is easy to see that a certain number of fibers from the general "mixed" nerves pass without interruption into the skin and so do not participate in the formation of the plexus. Others, on the other hand, divide dichotomously in the level of the plexus and the branches give off "collaterals" that pass through the corium and so reach the epithelial layer. It is not possible to state positively that fibers from the ganglion cells of the plexus give off fibers to the skin, though such certainly is the appearance. After passing through the corium, the fibers do not all at once seek out their definite termini in the cells of the epithelial layer, but they often turn sharply at right angles at the ectal surface of the corium and pass long distances parallel to the surface. This tendency is more marked in some regions than in others. This fact greatly complicates the study of the endings. In the case of taste buds and the organs of the lateral line this is one of the most serious difficulties in the way of a correct interpretation of the appearances presented by sections.

A discussion of the theoretical bearings of these facts and further details must be deferred to the second part of this paper.

Since writing the above we have been able to settle several points previously in doubt. None of our preparations of the skin of amphibians gave unambiguous results for the glands of the skin. We have at last succeeded in securing excellent *intra vitam* impregnations in the toad (Bufo sp.) in which it is easy to trace the non-medulated fibers from the plexus ectad of the corium, and also from that entad of it, into the most intimate connection with the superficial walls of the glands, which in this species are very large and highly functional. The fibers are of small caliber but are excessively numerous and envelop the whole gland in what at first looks like a closely woven reticulum, but a close study shows that the appearance of a reticulum is due to the repeated dichotomous branching of a large number of distinct nerve fibers. These fibers cross at slightly different levels and there is no doubt in most cases of the complete distinctness of the fibers as they cross. Upon these fibers are frequent varicosities which may be due to imperfections of the process or may be the points of attachment of the fibers upon the cells of the gland. Of course this method does not admit of determining the exact relation of the nodosities to the several cells, but there can be no doubt of the existence of a very intimate and necessary connection. One is forcibly struck by the close resemblance of this periglandular felting to the perigemmular reticulum described by many authors in the case of the sense buds. The latter is, as we have before insisted, entirely distinct from and totally unlike the intragemmular endings in distinct cells which may be demonstiated by a wide range of independent methods.

The same preparations used in the earlier parts of this paper have also afforded to a more extended study a number of satisfactory views of the connection of the ganglion cells of the reticulum below the corium with fibers—not only with such as pass directly into the nerve bundles but, as we now find, with with non-medullated fibers which pass through the corium and end in relation with the cells of the epithelium layer. We also find that these and other fibers, after passing through the corium, turn and pass for long distances parallel to the surface to their final destination in the upper layer. This seems to be particularly true of the fibers of the perigemmular series of the sense buds. In some cases well defined bundles of nerves in a common sheath pass through the corium, while in those cases where the nerve sheath is present it is soon lost after passing the corium. It seems natural to conclude that the non-medullated fibers of the epithelium are essentially similar to the fibers of the same structure that supply the glands. If so, we may add that these are in both cases centrifugal and we have a suggestisn at least toward the solution of the puzzle as to the respective functions of the several classes of fibers. That the general cells of the skin have more or less power of absorption and excretion, as well as secretion, can hardly be doubted and, if so, why may not these fibers from the disperse ganglia of the peripheral sympathetic system be the neural sponsors for these functions? The methylene blue method reveals the same sensory endings in the skin that we have described fully from histological preparations, but curiously enough they appear as fibers simply because the nuclei are not stained and this fact explains the discrepancy in the two methods.

It is interesting to compare the intercellular net-work described above with the similar so-called connective tissue network described by Bruyne (Arch. de Biol., XII, 1892) surrounding the muscle fibers. The figure given in the article by the same author in Anat. Anzeiger, X, 18, is so remarkably similar to the apearance we have called attention to that one may be pardoned for suspecting similarity of nature. It may be that more than one instance of intercellular bridges rests on the misinterpretation of similar structures. The relation of the space so kept open between the cells to the circulatory fluid is a question of greater interest than seems to have been suspected.

NOTE ON THE METHYLENE BLUE PROCESS. It appears that we have had in one respect the usual experience with the methylene blue *intra vitam* impregnation process. It is not difficult to secure excellent impregnations of the nerves of the skin of the Amphibia in which the nerve fibers are deeply and quite selectively stained, yet it appears that there is a strong tendency for the stain to be extracted or rendered diffuse by the process of imbedding so that tissues which were very perfectly stained in the glycerine are quite unsatisfactory in thin section. It appears that the difficulty is in the action of the alcohol, which is required in both the paraffin and the celloidin methods of imbedding. To obviate this difficulty we have resorted with good results to the use of a mixture of gum arabic and glycerine. The fragment is placed in glycerine or may be placed at once in the gum-glycerine. After an impregnation of a day or two in a closed bottle the specimen is mounted in a paper tray with the mixture and the latter is allowed to evaporate till a consistency is reached which will permit it being placed in the microtome and sectioned. In this way sections are secured thin enough to serve the pupose desired and these may be mounted in gum-glycerine or may then be dissolved out of the gum and treated in any way desired.

EXPLANATION OF FIGURES.

PLATE V.

Fig. 1. Diagram of the skin of the sexual organs, after Dogiel.

Fig. 2. End-organs in the skin of the tree frog, original. Teased preparation.

Fig. 3. Sense bud of young salamander. Original.

Fig. 4. Skin of tadpole with nerve endings and the transitory skeins interpreted as nerve endings by Pfitzner.

Fig. 5. Skin of very young tadpole. Original.

Fig. 6. Skin of tadpole, near angle of mouth, Original.

Fig. 7. Sense bud of Amblystoma. Original.

Fig. 8. Nerve endings in the epithelium of the frog, according to Bethe.

A.—"Gabelzelle," from sensory papillæ of tongue.

B.—Cylinder cells.

C.—Isolated rod cell.

D.—Upper part of papilla.

E.—Ciliate cell of palate.

Fig. 9. Nerve ending in the human conjunctiva. Dogiel.

Fig. 10. Nerve endings in Jacobson's organ. Lenhossèk.

Fig. 11. Nerve endings in the taste buds. Arnstein.

PLATE VI.

Fig. 12. Section from the skin of the head of a tree-toad. *a*, nerve bundle and endings; *b*, gland; *c*, corium; *d*, small gland; *e*, chromatophore.

Fig. 13. Skin of head of leopard frog showing cellular nerve endings in groups penetrating the skin.

Fig. 14. Similar endings from the tree frog.

Figs. 15, 16. See Plate VIII.

Fig. 17. Part of the skin of the axolotl showing the nerve bundle on its way to the skin and the pericellular net-work.

Fig. 18. Skin of axolotl showing pericellular net-work and the nerve-fibers entering from below.

Fig. 19. Similar section fixed in Flemming's solution.

Fig. 20. A section of portion of axolotl skin where the Leydig cells (*L. c.*) are two-layered. Proliferating cells (*k*) in lower series of protoblasts; *c*, corium; *B. V.*, capillary; nerve fibers entering from below.

Figs. 21-23. See Plate VIII.

Fig. 24. Skin of tadpole as figured by Pfitzner.

PLATE VII.

Fig. 25. Section from a different part of the skin with cellular nerve termini. This is probably to be explained as the result of the elongation of the basal series of the epithelial cells.

Fig. 26. Sensory bud from skin of axolotl, showing the tubular peripheral ending of sensory cells with fine thread of protoplasm extending to periphery and the basal connective with nerves.

Fig. 27. Sensory bud from another part of skin.

Fig. 28. Similar bud in which the peripheral portion of the sensory element seems divided. Explained as due to the shrinkage and " fraying out " of the wall.

Fig. 29. See Plate VIII.

Fig. 30. Isolated supporting cells from specimens similar to Fig. 28, stained with hæmatoxylin, picro-carmine and methylene blue. Are the blue fibers nerves, or are they lines of precipitation in folds of the cell wall due to shrinkage? Compare Fig. 11.

Fig. 31. Cells from nasal cavity of leopard frog.

Fig. 32. Nerve endings from skin of same to illustrate similarity to the last.

Fig. 33. Skin of gills of axolotl to show ganglion cells beneath the corium.

PLATE VIII.

Fig. 15. Pericellular nerve fibers from sensory bud of conger eel.

Fig. 16. Intrabulbar endings in *Barbus.* (Both 15 and 16 from Lenhossèk.)

Fig. 21. Skin of the axolotl showing nerve endings in or near the chroma tophores and in the skin of the axolotl. Methylene blue.

Fig. 22. Similar to Fig. 21, showing endings in layer of protoblasts.

Fig. 23. Perpendicular section through skin of axolotl stained *intra vitam* with methylene blue and cleared in glycerine. The plexus beneath the corium. is clearly visible.

Fig. 29. Cells similar to to Fig. 28, stained with methylene blue.

Fig. 34. Surface view of methylene blue preparation, similar to Fig. 33, showing connection of ganglion cells with nerve bundles.

Fig. 35. Same as Fig. 34.

Figs. 36, 37. Ganglion cells of large ramose form from same layer as above.

Fig. 38. Relation of nervous reticulum below the corium to the capillaries.

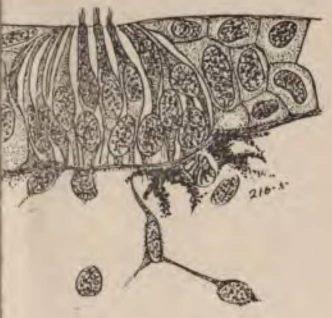
Fig. 39. Chromatophore-like ganglion cells.

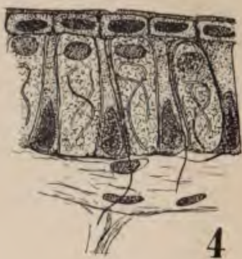
PLATE IX.

Fig. 40. Section of the skin of the head of a toad (Bufo) after *intra vitam* injection with methylene blue and fixation with Bethe's solution of molybdate of ammonia. Examined in glycerine. The section is somewhat oblique so that the duct and part of the body of the gland is removed. The delicate non-medulated fibers are seen generously distributed over the uncut surface of the gland. Coarser fibers are also seen in the lower and upper plexuses, also a bundle of sensory rods at the left.

Fig. 41. Intra vitam methylene blue preparation of skin of axolotl, showing connection of cells of the ganglionic meshwork beneath the corium with the epidermis. *a*, fiber passing to cells of the intracellular reticulum; *b*, non-medullated fibers from a nerve piercing the corium; c, c,^{1} c^2 and c^3, ganglion cells of the plexus beneath the corium.

PLATE V.

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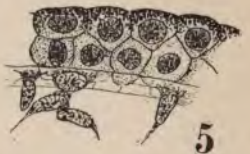
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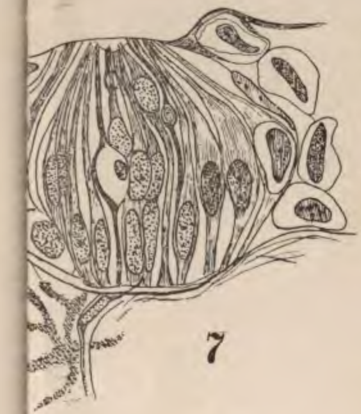
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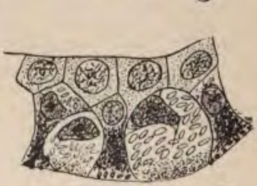
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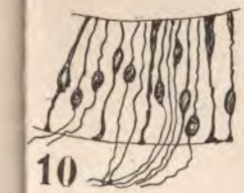
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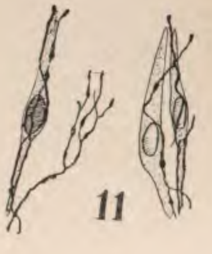
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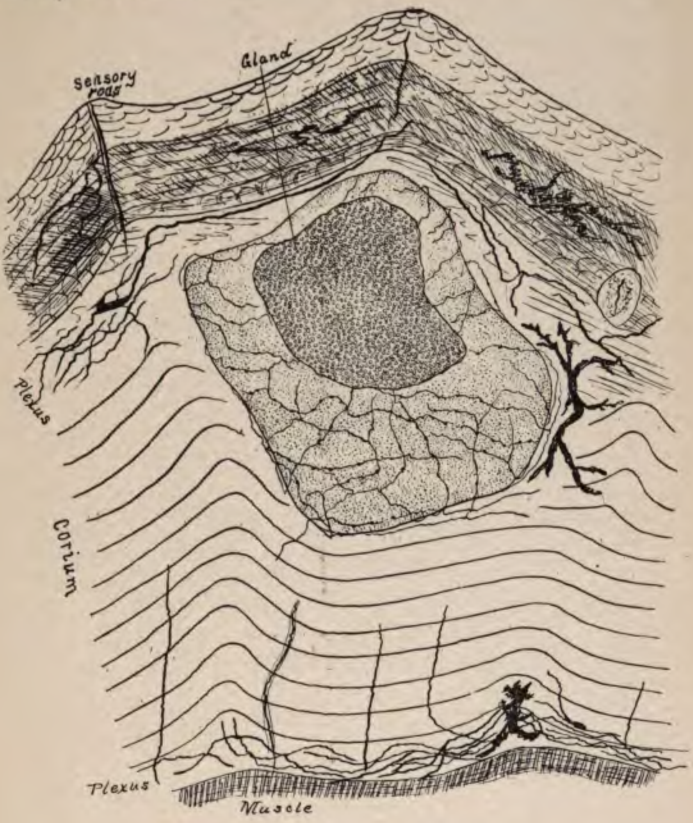

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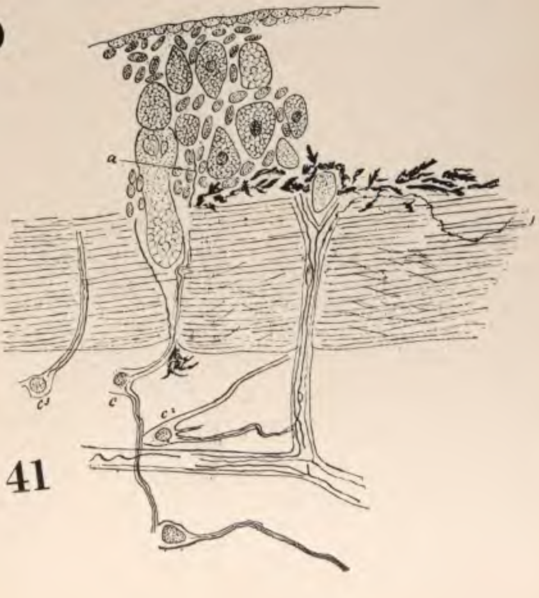

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THE GEOLOGY OF THE ENVIRONS OF ALBUQUERQUE, NEW MEXICO.

By C. L. **Herrick**, Albuquerque, New Mexico.

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THE GEOLOGY OF THE ENVIRONS OF ALBUQUERQUE, NEW MEXICO.

By C. L. Herrick, Albuquerque, New Mexico.

(Plate VI.)

It is somewhat surprising that the geology of the valley of the Rio Grande in New Mexico seems to have escaped attention, while the more inaccessible parts of the territory have been the subject of elaborate memoirs. The small area about the metropolis of New Mexico which forms the subject of this paper is not wanting in interest from many points of view, but it seems never to have received more than passing attention, while the large area of the Mount Taylor district to the west is the subject of the interesting and elaborate monograph by captain Dutton.

The area covered by this report is, roughly speaking, a square of twenty miles, with the city of Albuquerque at its centre. Its study has been carried on in intervals of the administrative work of the University and cannot hope to be exhaustive, yet we trust that a foundation has been laid for a more minute study of the valley at other places. The attempt to secure information at second hand has proven futile, for the few who in this region are sufficiently interested to observe natural phenomena are not well enough versed in the elements of geological interpretation to report correctly the facts observed. The writer gratefully acknowledges the assistance of Prof. E. W. Claypole, a former colleague in the geological study of the Waverly of Ohio, who accompanied him upon several of the expeditions upon which this paper rests. Although the conditions here reported are in a sense local, it is upon the accurate comprehension of these details that the intelligent survey of the general geological outlines must rest. A map with contour lines and details of distribution is in process of construction and will be issued in the forthcoming bulletin of the University of New Mexico.

I. THE ALBUQUERQUE RIVER DEPOSITS.

The valley of the Rio Grande at Albuquerque offers a number of interesting geological problems, some of which when solved may prove of far-reaching importance for the interpretation of the general surface geology of the territory.

To the east of the city, at a distance of about ten miles, the eastern wall of the valley is formed by a rather abrupt escarpment of gneisses, granites and quartzytes in what may have been the axis of a monocline. Near the base the abrupt ascent is broken by rounded foot hills, and the products of erosion from this granitic metamorphic series are to be found widely distributed in the valley gravels. Respecting the age of this formation it is only known that it is older than the coal measures, limestones of the latter age being everywhere present at the top of the metamorphic rocks.* In some places there are pebbles of granite in the silicious layers at the base of the Carboniferous, and unconformity may be assumed in many places, while the resemblance of the silicious strata interbedded in the limestones to the upper parts of the metamorphic series and the lack of apparent unconformity in some places suggests that the interval may not have been so long as has been supposed, or may occur lower in the series—a suggestion also made possible by the occurrence in the same relative position in the granite series at Limitar (fifty miles south) of a band of fossiliferous limestones at a depth of several hundred feet below the lime beds of undoubted Carboniferous age. The metamorphic series east of Albuquerque rises in places to a hight of 2,000 feet above the mesa or 300 feet above the river at the city. The dip is a few degrees (15-25) to the east, so that the irregularities of erosion as well as the varying amount of uplift brings the Carboniferous beds at some places much nearer the mean level. If the mesa east of the river is really in the axis of an anticline, as has been suggested, it must be admitted that the western wall has been entirely removed at this place. If, on the other hand, the fold was a monocline the whole western portion has been faulted hundreds of feet below the river level. Nearly opposite Albuquerque the river gravels are much obscured by sand drifted from the mesa to the westward which is underlaid by sands of a relatively late period (Cretaceous).

From five small volcanic cones a small sheet of basaltic lava has spread over an area of about twenty-five square miles with an irregular front upon the river of about five or six miles. Along this river front the basalt varies from six to twenty feet in thickness and is quite vesicular, especially at the top, and it reposes on substantially horizontal beds of sandstone of the same age apparently as that forming the mesa back from the river, though there are one or more benches of river drift nearer the river. So far as seen, the material capped by the basalt does not contain the trachyte, andesyte, rhyolyte or basaltic pebbles occasionally found in the river drift, though it contains quartzyte and limestone fragments and also fossil woods. This point is worthy of careful study, for by this means it may yet prove possible to ascertain the age of the eruptives which are so characteristic of the region further north and south. At any rate, the evidence so far at hand seems to indicate that the lava flows here are older than the river gravels, since we have yet to find a place where the lava overtops the fluviatile formation, while near Isleta we do find the river gravels overlying the basaltic flows. Much depends upon the correct estimation of the age of these lava flows, inasmuch they are said to cover ancient pueblos, and in some cases maize has been found in a charred state below the lava. Near Isleta, an Indian pueblo about twelve miles south of Albuquerque, there is another such a flow and the underlying sandy layers have here been greatly indurated and reddened. In this case there are at least fifty feet of the Cretaceous (?) sandstones and shales below the lava, but the elevation is not uniform, so that near the southern edge the lava—there only about eight feet thick—is covered in places by the river gravels.

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*We have been unable to verify the reports of fossils older than the Carboniferous in any part of the Rio Grande valley.

Near the northern end of this flow there is an insular patch of the lava cut off from the main flow by a narrow valley of erosion which must have been at one time the channel of the river or an arm of it, and this at a time when the river was somewhat higher than at present.

These facts with others, the details of which need not be given here, make it apparent that the local basaltic lava flows have occurred at a date more recent than the Cretaceous deposits beneath them and at a period earlier than that of the river gravels. Whether the latter are of approximately Champlain age or not must be left to the future to determine, but it is a matter of no small interest to ascertain the age of the several eruptives more definitely in view of the relation already noted with human remains preserved beneath them. The possibility that these isolated flows may differ greatly in age is not to be forgotten, though the essential lithological and structural similarity of the rocks as well as the similarity of the methods of occurrence suggest a close agreement in age.

Having thus briefly indicated the environs or limits of the river deposits we may turn our attention to the latter as they are represented at Albuquerque. These beds are exposed at various points in the immediate valley of the present river. The banks formed by the erosion of the older flood plain are often as high as seventy-five feet above the present river bed below the city. This plain is a large mesa extending from the bluffs to the foot hills on the east and the surface is nearly flat but with a gentle upward slope to within a short distance of the mountains whence the inclination to the base is more rapid. The uppermost of the deposits of this mesa and that which lies at or near the surface where un-eroded is a curious yellowish-white marl, which is apparently about six feet thick and can be traced at about a constant level in the immediate river bluffs to a point south of Isleta, as well as north to Albuquerque and eastward to within a mile or two of the base of the mountains. South of the arroyo formed by the outlet of Tijeras canon in the Sandias the mesa is immediately underlaid by this deposit so that it is thrown out by burrowing rodents. A curious feature of this plain is the occurrence of numerous slight depressions thickly distributed over the area. These are rarely more than five yards across and commonly are from eighteen inches to two feet deep and are provided with a raised border. They might be taken for buffalo wallows were it not for their great abundance and general distribution. These depressions seem to hold water as they sink to the level of the marl. This marl, which may henceforth be known as the Albuquerque marl, has been detected on the western side of the Rio Grande as far south as Belen, thirty miles south of Albuquerque. The composition of the marl is largely calcareous, though it contains small pebbles also. Near the city there has been so much erosion that its horizon could not be reached for some distance beyond the

University campus, but further south it is quite conspicuous as a white band near the summit of the bluffs for many miles. The following is the partial analysis made by Prof. R. W. Tinsley, chemist of the university.

SiO_2	26.53
Fe_2O_3	1.20
$CaCo_3$	64.47

It will be a matter of considerable local interest to determine the conditions under which such a marl could have been formed. If one could find evidence of a dam below Albuquerque, which at the time when the flood plain had reached its highest point could have formed a great lake or estuary, it could be supposed that highly carbonated water from the limestone areas to the east may have spread over the bottom this rather uniform layer of calcareous material. The formation of such lakes or quiet spots on a small scale in the river valley has other illustrations. Or one might be tempted to think of wide-spreading flows of volcanic waters charged with a material sedimented out on cooling. That the marl is not a purely local deposit is proven by its occurrence on both sides of the river.

Beneath the marl is a considerable band of gravel and rounded stones of variable size. The materials are chiefly quartzytes, gneisses and granites, evidently the debris from the metamorphic series already mentioned, though fragments of andesytes, trachyte, rhyolyte and basalt are also found. In some places the gravels on the east side of the river contain scoria and basalt evidently of the age of the recent cones of the west side of the river, suggesting an extension of those flows to the east of the present river. And as fragments of petrified wood occur with them we may also conclude that the underlying materials in this place were of the same age as where exposed elsewhere,—namely Cretaceous. The thickness of these gravels may vary from two to twenty or more feet. Beneath these appears a sandy loess passing into clay sometimes carrying fragments of undecayed wood. The depth of this stratum is as yet but imperfectly known, but it is eminently characteristic and may be recognized everywhere in the immediate bluffs of the river. In some places it has a clayey consistency, while more often it is composed of fine grains of sandy material. About Albuquerque it is in request as a "molding sand," for which purpose it is well adapted. It is plain that this series, which we shall designate as the "*Rio Grande loess*," must have been deposited during a period of abundant but sluggish flow. The great extent and the horizontality of the series afford proof of these suggestions. The loess seems to repose upon the Cretaceous of the immediate valley of the river. The original inclination of the valley must have been greater than at the close of the loess period, for only ten miles above the city of Albuquerque the obliquely tilted sandstones of the Cretaceous appear in the river bed. It appears probable that in many places at least there is a stratum of coarse material between the loess and the bed rock, though the only direct evidence we have is from the reports of well-diggers who report a stratum of "cobble stones" as the water-bearing horizon at a depth of 350 feet upon the mesa three miles east of the University campus. It may be assumed that the river silted itself up during the period of quiet represented by the loess. If so, the re-excavation of the channel must have followed immediately, for, as above stated, the next number of the series, the "*Rio Grande gravels*," is an exceedingly variable quantity. It is a coarse or moderately fine deposit of the most diverse materials. Among these the granitic and quartzytic fragments from the neighboring mountains may be said to predominate, yet there are localities where the entire deposit is composed of volcanic scoriæ. In a previous paper the writer has described the instance further down the river where an isolated basin has been filled with floating pumice, which deposited by its own abrasion the so-called Socorro tripoli. A somewhat similar instance has since been found about nine miles north of Albuquerque where a large deposit of the same character may be seen from the train. Large quantities of the dark basalt of the local flows along the valley are noticed everywhere in these gravels together with rounded fragments of andesyte and trachyte derived from the older eruptives penetrating the stratified series of the valley margin. The upper surface of the loess is everywhere deeply eroded and in the irregularities so produced are deposited the coarser elements of the gravel.

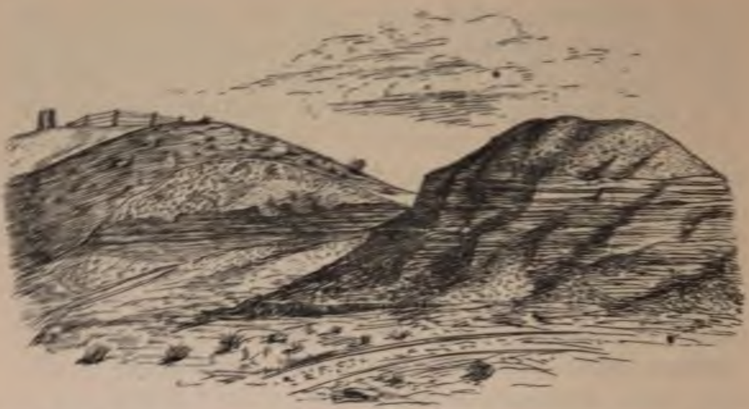

FIG. 1. An exposure in the suburbs of Albuquerque showing the eroded upper surface of the Rio Grande loess with the irregularly banded gravel reposing upon it.

Fig. 1 illustrates such an instance in the banks whence molding sand has been removed at the eastern end of Lead avenue in the city of Albuquerque. Not only are the deposits of gravel very irregularly distributed, but it appears that they are mostly collected in the centre of the valley or near the present river bed. It would seem safe to assume that these gravels represent a torrential period in the history of the river and that accordingly this was a period of active erosion, of numerous changes in the river, and corresponding irregularity of deposition. The river must have stood at times at a high level, and it may be that this was a time of breaking away of old barriers. The loess must have been high enough to have caused the river to flow over some of the recent lava sheets of the valley, as is shown by the abandoned channels at various places in the lower course of the river. In fact, one is almost irresistibly reminded of the conditions in glaciated regions, where old river courses are continually being revealed. Yet in these cases it would seem that the direct agency of ice is excluded. One such instance is to be described beyond, while a still more extensive occurrence in the neighborhood of La Joya may form the subject of a later contribution. It was at first thought that the river had been dammed at these points by flows from the adjacent craters, but as further examination seemed to show that the flows were older than the loess and certainly older than the gravels which are, in places, found reposing on the top of these flows, and as it seems necessary to seek some explanation of the superposed marl, we must probably look for some later agency to account for such dams. Perhaps flooded conditions of affluents below may give us the clue. It will be necessary to correlate the above described facts with the conditions existing in the headwaters of the Rio Grande before all the elements in the problem can be fully understood, yet it is not hard to see that in a general way the record is of a river whose upper tributaries were under the influence of the permutations of the Glacial period.

II. THE ISLETA VOLCANO AND THE PARIA MESA.

In the valley of the Rio Grande in New Mexico is situated the ancient pueblo of Isleta, well known through the writings of Lummis, who lived there for some years while studying the native races. This village is about twelve miles south of Albuquerque in the flood plain of the present river, above which it is raised upon what may have been a natural eminence of no great hight but which has been added to by accumulations of unnumbered generations. Although the pueblo is modernized to a great extent it is still inhabited by the same race as at the earliest known date, and these Indians eke out their livelihood, derived from the fields and orchards in the vicinity, by the sale of pottery and trinkets which the squaws offer to the travelers on each passing train.

It is not with the village nor its inhabitants that this paper is concerned, but rather with the interesting geological environs. The Rio Grande is now a sluggish stream as muddy as the Missouri and nearly as changeable within the narrow limits of the recent gorge. But the valley is full of evidence that the river was not always the comparatively tame and ineffectual irrigation purveyor it now appears. The description of the valley deposits is given elsewhere, and it is only necessary to say here that the broad valley was at one time filled to the hight of about 350 feet above present water level, and data are yet wanting to indicate how much deeper fluviatile deposits may extend. At least three divisions in the river bluffs have been identified. The base of this "Rio Grande series," so far as known, is a thick bed of loess or fine detritus of a yellowish color and containing few large pebbles, but a larger number of what seem to be fragments of granitic debris. The upper portions especially contain numerous white chalky grains that may be simply the kaolinized remains of the feldspathic fragments. Although the oldest of these beds, the loess nevertheless contains fragments of unaltered wood in some places. The upper surface of this Rio Grande loess is irregularly eroded and upon this eroded surface there reposes a layer of shingle pebbles of considerable though indefinite thickness. It may be roughly estimated at an average of twenty-five feet. The upper part of this bed of Rio Grande gravel is variable in nature, but everywhere in the vicinity of Albuquerque where the uppermost deposit is preserved it is found to support a band of white chalky material which we shall call the "Albuquerque marl."

The present gorge of the Rio Grande in the vicinity of Albuquerque is not more than two or three miles wide in most places and this small flood plain is dotted with ranches and villages. From the west at several places the flood plain is encroached on by abrupt lava-capped bluffs. One such is adjacent to Isleta and extends from a point just west of the pueblo for three to four miles northward. The first thought is that the flow forming the cap has taken place since the river gravels were deposited, for the material covered is a sandy and horizontally stratified deposit not unlike the finer forms of river detritus. The source of the lava, which is a black, rather vescicular basalt, is near at hand, being a small volcanic cone about three miles northwest of the pueblo and not more than three to five hundred feet above the water level of the river. The eastern wall of the crater has been broken away and the latest flow has accordingly been toward the sea, in which direction it may at one time have extended in long radiating streams from the main sheet as far as the present river bed, though these outlying portions have long since been carved down by the river and only great piles of debris remain, and the greater portion of this material is doubtless buried beneath the sands. The bluff remaining looking toward the river, is exceedingly irregular, but in hight is quite constant, being about 100 feet at the portions lying to the north but sinking to less than thirty at the southern limit.

The north and south length of the area is about three or four miles and the greatest thickness of the lava is not more than twenty-five feet at any point seen, though the thickness is not at all constant, but in some places is reduced to four or five feet. The appearance of the upper surface shows that there was not a single wide-sweeping flow, but a somewhat intermittent series following in such a way that the older flows were in some cases overtopped by later discharges of the same material. In composition the lava is apparently exactly like that of the entire series of recent basalts of New Mexico, which will form the subject of a separate paper. A few miles further west is a second larger cone, the flows from which may prove confluent with that of the one now under consideration on the west. It is noticeable that these recent cones tend to be clustered in groups. The present group may be known as the Isleta group, comprising an east and west Isleta peak. It lies about ten miles south of the Albuquerque group. But the interest which attaches to this flow is quite apart from the character of the lava itself. As already indicated, it would not be unnatural to infer, in looking at the deposits as they lie in the valley apparently parallel to those formed by the river to suppose that these two are essentially the same—fluviatile sand and gravel accumulated by the river at a time when it was larger than at present, or when its bed was less inclined toward the south. If this were the case it would follow that the lava flows might be comparatively recent and such vestiges of man as might be found beneath the lava need not be assigned any great antiquity. But a brief study of the sub-igneous deposits in the Albuquerque group of cones seemed to point to a quite different conclusion. If they were really fluviatile these deposits were not a part of what has been called the Albuquerque series, for they are of a different lithological character. In the modern river gravels the pebbles are of gneiss and granite as well as quartzyte, but in addition contain great numbers of fragments of andesyte, rhyolyte and trachyte, i. e., of materials such as are found in the older eruptives of the valley. So far, these last-named elements have not been found in the sub-igneous deposits mentioned, but fragments such as may have come from the Cretaceous of the region to the west, if not of that age themselves, are commingled with the granitic debris. But in the midst of the perplexity growing out of the evidence that the river erosion of the time when the present gravels were deposited has involved these lava-topped bluffs, the study of the material below the lava of the Isleta cones has offered an unambiguous solution of part of the problem. At that place indeed the recent river gravels (No. 2 of the Albuquerque series) are in places to be seen actually overlying the lava and forming extensive beds upon its surface. On the other hand, as stated elsewhere, fragments of the lava and of pumice have been found in No. 2 on the opposite side of the river, An examination of the materials below the flow at Isleta shows that they are largely composed of sand grains of apparently granitic origin. They are mostly quite fine and only rarely do large pebbles occur. Close inspection shows that in many places there is a large admixture of small black grains of a rather obscure nature. Fortunately a place was found at a point nearly due east of the crater where the whole matter is explained. Here the thickness of the underlying gravels is exposed for about fifty feet, and the lava is very irregular. In some places it is fifteen to twenty feet thick and in an adjacent part it is less than five, while in other places the lava never has flowed over the gravel beds. The latter, in those portions in which they are, or have been, covered by the lava, conforms to the irregularities of the under-surface of the flow so that, as the deposits are very clearly and minutely stratified, there is no question of erosion prior to the flow sufficient to account for the irregularities. Different parts of the stratified gravels are unconformable to each other, as might be in a current of changeable character with great burden of detritus. But the clue to the nature of these deposits is found in the fact that in the midst of this stratified deposit and scattered through it from top to bottom of the entire exposure are large angular blocks of basalt quite like the material of the flow and varying in size from the diameter of one's head to that of a pea, arranged irrespective of stratification, though in some places there are bands filled with small grains of a similar character. The appearance of the exposures is curious in the extreme for the mass is so minutely stratified and its materials so plainly the detritus of sedimentary deposits that the agency of water is proven, while the arrangement of the angular blocks is like that of glacial boulder clay. The inclination of the strata is slight but obviously in a direction radiating from the cone of eruption. It would be natural to think of volcanic ash or mud but the materials do not admit of this conclusion. We are shut up to the view that at the time immediately prior to the last eruption of the Isleta crater there was a great out-flow of water from the crater, accompanied by explosive fragmentation of pre-existing lava whose pieces were either intermittently thrown from the crater to be lodged in the pasty mud hurried along by these flows, or caught up in the current and after lodging by their own weight, finer material was settled about them in the process of sedimentation. This mud-flow evidently extended beyond the subsequent flow of lava, for such banks are exposed with their freight of lava blocks but without the settling and distortion resulting from the weight of the lava. Incidentally it may be learned that the lava flow followed soon after the water, for it can easily be seen that the weight of the lava caused great displacement, especially near the edge where the still pliant material was squeezed beyond the edges. The upper surface of the sand is baked and browned more than in other places, and a great deal of silicious matter has been incorporated into the under layers of the lava, thus proving the presence of water at the time of the flow. The finer particles of basalt were, of course, carried according to the same law as the other ingredients of the material caught up by the gushing waters. Much yet remains to be done in ascertaining the extent of the deposits from such floods. That the quantity of water must have been enormous is plain when we note that nearly a hundred feet of the material certainly was deposited over many miles, while the actual thickness may have been much greater. (Figs. 1, 2 and 3.)

This instance has a special significance in establishing the fact that in connection with the lava flows of the basaltic series there occurred great floods of hot water which may well have been highly charged with gases and silica. Thus it seems possible to account for the great areas covered with silicified wood in the western part of the territory and Arizona. Such great floods would undoubtedly produce lakes of silicious

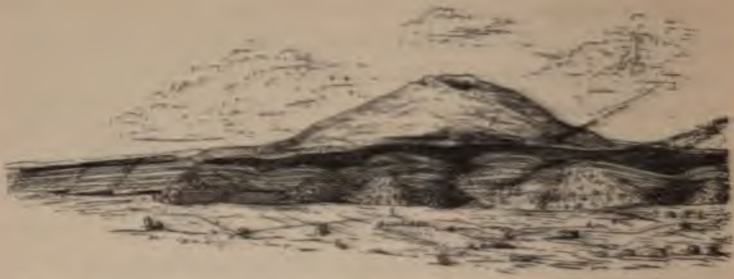

FIG. 2. The Isleta volcano. In the middle ground the abrupt escarpment of the lava-topped mud flows from the volcano.

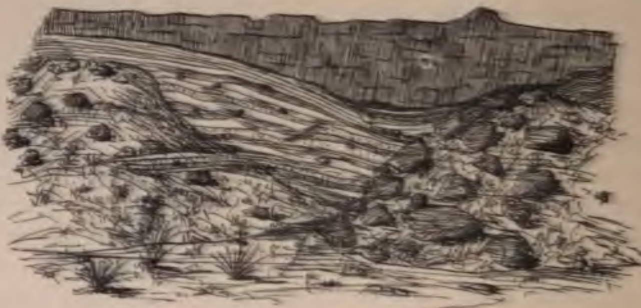

FIG. 3. Portion of the same as shown in figure 2 to show the fragments of basalt scattered in the stratified mud.

water in which trees might become impregnated with silica, or more probably a mass of such pasty material charged with silicious water would be a still better means of altering imbedded trunks. Of course, the age of these flows is still to be determined, though it may safely be placed at an earlier period than that in which the river gravels were deposited, that is, earlier than the post-glacial or Champlain period. It would appear that the silicification of the forest beds must have been in a general way contemporaneous with the sand accumulations, but the trunks are sometimes found in sandstones supposed to be not later than the Cretaceous. Still further, the finding of ears of corn imbedded in the lower surface of the flow of lava in certain places might then be thought to take human occupation back to that period, but it is plain that at present no such wide generalization is warrantable, though the above-mentioned facts point the way to the final settlement of the larger question as to the age of man in New Mexico.

The Paria Mesa.

In connection with the flow at Isleta above described, another problem is to be noticed. About two and a half miles north of Isleta a part of the lava-topped mesa extends far out into the valley. It is here nearly one hundred feet high, though the lava is rarely more than ten to fifteen feet thick. (Fig. 4.) The talus is very steep. This area of about one quarter mile in length and a little more than one-half that in width has been cut off from the rest of the area by what must have been an arm or old channel of the river at its highest. This cut-off is nearly north and south in its course and is blocked at its northern end by bars, part of which may be due to drifting sand and more to bars accumulated when the river swept in an arch near the entrance, as there is evidence that it did at no very remote period. The bluffs of the western bank of the river are here a considerable distance further west than the opening of the old channel, and there are remnants of both the loess and the gravel deposits, i. e., numbers one and two of the Albuquerque series. Similar gravel is found on the summit of the mesa. Near the northern end of the old channel is the small village of Paria, and the town is supplied from rather shallow wells, showing the existence of the river channel at that place. This ancient channel raises the interesting query as to the conditions which could have

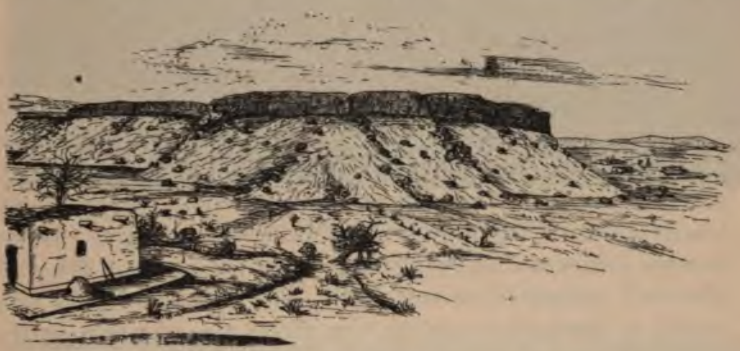

FIG. 4. The Paria mesa. The old river channel is to the left.

resulted in so blocking the main channel as to cause the stream to cut through this solid mesa. May it have been that the flow of mud due to the water from the volcano dammed the stream and caused this side erosion, or, what is more probable, that the filling up of the old valley by the loess and then the gravel lifted the level of the entire valley so high that the water found its way over the lava area and then, when the gradual removal of the glacial detritus below reduced the level, the water wore through this sheet of lava and excavated the new channel before that removal had opened up its old channel.

In this connection it may be noticed that upon the summit of this insular mesa there is what seems to be the remnant of an aboriginal fortification consisting of two walls of stone meeting at a right angle to the northwest, the longer extending south about 100 yards, the other east about seventy-five yards. At present the walls are loose ridges of lava blocks about six feet high and ten to fifteen feet wide. There is some evidence that the ground on the inside near the wall has been excavated several feet. The outline of only one pueblo of small size could be seen within the area thus partly protected, though chipped flints and potsherds are numerous. It seems hardly likely that the embankment was raised against water, and, in fact, there is at the angle an opening in the west wall like that of a sally port or door. The basaltic walls of the mesa and fragments at its base are covered with aboriginal tracings in which the figure of the turtle and the four pointed star seem predominant.

III. THE BERNALILLO VOLCANO.

The town of Bernalillo is sixteen miles north of Albuquerque on the east bank of the Rio Grande. At this point the Cretaceous emerges boldly from beneath the river gravels and loess. All the river deposits betray the influence of the Cretaceous below some time before the latter actually outcrops. Opposite the town and for some miles to the northward the river is bordered by long horizontal bluffs capped by basaltic flows of no great thickness, but of many miles extent. These bluffs afford the most instructive illustration of base-leveling that could be imagined. (Fig. 5.) The basalt re-

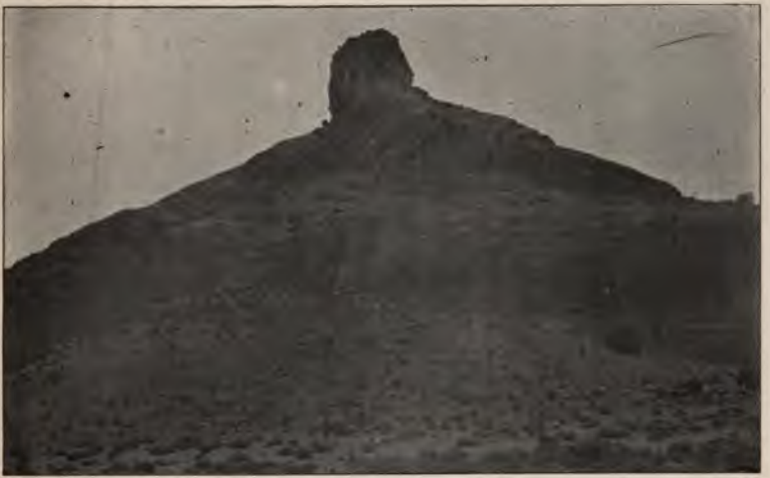

FIG. 1. Neck of the Bernalillo volcano.

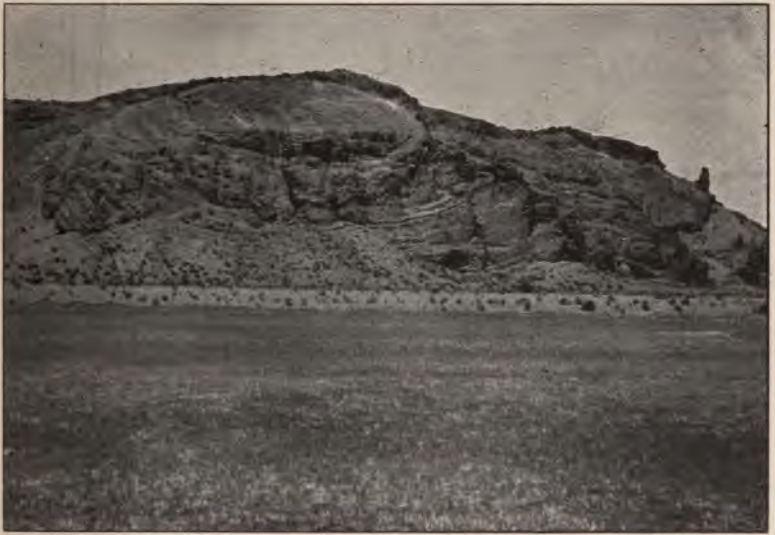

FIG. 2. Adjacent part of the stratified material showing dykes from the neck and the disturbed strata.

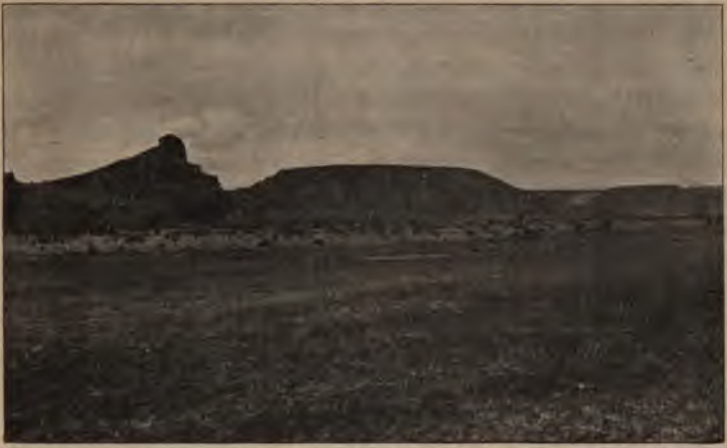

FIG. 5. More distant view of the neck of the Bernalillo volcano and the lava-topped mesas beyond.

poses on the red and grey Cretaceous strata, which remain nearly horizontal. The sources of these flows is not difficult to locate in local craters which penetrate the Cretaceous at various places. The erosion of the river has done a very useful service to the geologist, in removing, to a large extent, the soft strata about one of the old cones and exposing the true inwardness of the eruption when occurring in soft materials. In fact, it may be said to afford the necessary supplement to the data from the Isleta volcano. Here, as in that case, the lava forced its way through the soft Cretaceous strata, and here also the outbreak seems to have been attended with a great flood of hot water which has redistributed the materials. In one place (Pl. VI., Fig. 1) erosion has exposed the "neck" or original column of lava which cooled in the throat of the crater, and one may see the long dykes of basalt radiating in various directions into the soft displaced sand (Pl. VI., Fig. 2). These radiating dykes formed ribs to which the plastic sand mixed with fragments of the basalt adjusted itself. In the vicinity of these dykes there is often a small amount of metamorphism roughly proportionate to the thickness of the intruded mass. There is much reason to suppose that the other volcanoes of the valley are not later than these mentioned.

In the immediate environs of Albuquerque there are no complete exposures of the Cretaceous, but at a point on the west side of the Rio Grande about three miles northwest of the bridge at Los Corrales there is a fairly good continuous exposure of sands and marly lime referred to this period. The rock is very slightly coherent—scarcely more than a crag—and occurs in bands of red, yellow and white, while near the top is a narrow band of lime containing some imperfect remains which have not yet been studied. The entire thickness exposed is rather over one hundred feet, of which the lower half is of red sand with nodules of greater consistency. Some layers are quite firmly cemented. Near the top of the light-colored division the sand is loose and contains numerous pebbles of red and black chert, quartz, quartzyte and other materials apparently of granitic origin. It appears that this Cretaceous series is the country rock back from the river and that it has furnished a large part of the materials for both the older and the more recent river deposits. The valley nearer the river at this point is filled with materials similar to the portion about Albuquerque, the loess being below and overtopped by coarser material deposited on the eroded surface of the loess in sand-bar formation of the most interesting sort. Prominent among the coarser materials are fragments of basaltic lava evidently derived from flows higher up the river. No such material is seen in the Cretaceous gravel beds. Respecting the latter it may be noted that these beds are similar to those occupying the hills northeast of Socorro, where they are conspicuous by reason of their colors and stratigraphic distinctness.

IV. THE ALBUQUERQUE VOLCANIC GROUP.

A good illustration of the circumscribed lava flows from the latest eruptive cones is seen about six miles west of Albuquerque. Here five small cones rise in a group from the western crest of the valley. The axis of the group is north and south. Each cone may be the core or plug of the original crater, but, in that case, the walls of the crater proper have disappeared. It is claimed that there are evidences of local heat and vapors, but of this we have no evidence. The lava is a black vesicular basalt, and it extends in all directions, but especially to the east and south in an irregular sheet for several miles. Probably the greatest extent is not more than five miles from the cones, though the abrupt face as seen from the river is probably six miles long. The inclination of the flow is slight, not over two or three degrees, and at the exposed margins the thickness is often less than ten feet, though at points nearer the cones the thickness is somewhat greater. It is a matter of some surprise that so thin a flow should have proven so long fluid as is implied by the great extent of nearly level country covered. In some places the river has exposed a nearly perpendicular bluff over fifty feet high capped by this flow, and with the sides and base protected by the angular blocks. Along the southern face, on the other hand, the slight erosion of arroyos has served to expose the underlying strata of sand and gravel without having displaced much of the lava, as is proven by the relatively limited talus and the uncovered strata of adjoining hills. These strata differ from the recent fluviatile deposits in appearance and contents. The upper portion is but slightly indurated and the pebbles included in it are largely quartzyte, chert and lime. The beds are horizontal but differ from those nearer the river which contain materials like those which are derived from the granites and gneisses of the Sandias to the east. Fragments of silicified wood occur in the beds covered by the lava. They may, therefore, be of Cretaceous age, though it will be an interesting problem to determine whether the flow at other points did not run over the river gravels.

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THE OCCURRENCE OF COPPER AND LEAD IN THE SAN ANDREAS AND CABALLO MOUNTAINS.

By Pres. C. L. HERRICK, Albuquerque, New Mexico.

A somewhat interesting occurrence of copper in the mountain chain lying on the east side of the Rio Grande valley may be most easily understood from the conditions in the San Andreas, which lies some ten miles east of Lava station south of Socorro. The railroad here seems to pass through a syncline as the exposures of Carboniferous near the river dip to the east while the strata in the Andreas dip towards the northwest. To one approaching them from the east, that is from the plain of the white sands, the mountains present a rather abrupt escarpment rising nearly directly from the plain. The face is cut here and there by valleys and canons, but the configuration and geologic structure are remarkably uniform. The lower part of the scarp is composed of granite, gneiss or quartzyte of the metamorphic series and in this respect the conditions are precisely as in the Sandias and elsewhere in the ranges bordering upon the Rio Grande. Above this granite base rises the stratified series composed of Carboniferous limestone and interbedded sandstones with a thickness of 600 to 700 feet. In lithological and paleontological character this series presents no noteworthy peculiarities, but it differs from the similar exposures further north in the fact that the entire limestone series is cut by nearly vertical veins of considerable size which run about at right angles to the strike. These veins are numerous and occur at irregular intervals of a quarter to half a mile or more, and are so conspicuous that a number of them can be seen from the plain as depressed or elevated bands crossing the strata. The thickness of the veins varies also but many of them are from five to twenty feet thick and are filled with the most diverse materials. Some are silicious while others carry fluor spar, calcite, siderite, baryta, etc. While the veins can be traced to the contact with the granite they do not penetrate it, or if they do, it is only in the form of a narrow fissure. It would appear that the flexure which produced these fractures had more effect on the stratified than on the metamorphic rocks or that subsequent warping chiefly affected the upper series. At the juncture of the Carboniferous limestone with the granite there is often a thin band of red sandstone which has served to catch the leechings from the entire series above. Thus it happens that there has accumulated a band of hæmatite at this contact which is sometimes quite pure by substitution, but, in the majority of cases, is simply composed of a coating of the oxide covering the original quartz grains so that, when broken, every individual grain of the apparently oolitic ore is found to contain a quartz nucleus. Mining men have been deluded by this appearance into the attempt to use such material for iron flux; actually adding a rock with about 80 per cent silica to an ore requiring iron to assist in removing the excess of silica.

A very hasty glance at the situation is sufficient to explain the method of precipitation and segregation of the copper ores. The latter consist of copper glance, malachite, cuprite, and, in fact, nearly all the common ores of copper mixed with siderite and hæmatite and gangue matter. The sulphides of copper and associated silver must evidently have come in from below, rising possibly, in the circulating water, and it is equally plain that the iron band has accumulated by leeching from the superposed strata. At the lines of intersection and in the presence of air the precipitation has taken place. Comparatively little of the sulphides has collected below the contact (iron) zone and very little has passed beyond the iron zone to any great distance. It also appears that there is a diminution of the deposit at a distance from the surface.

The showing at the intersection is often very good and has been the cause of a great deal of profitless investment. It is possible to point out the places where such deposits will be found without doing more than to stand at a distance and note the points of intersection of the veins and the iron band so that the geologist gets credit for a great real of acumen for a prediction which is based wholly on a very simple metallurgical principle.

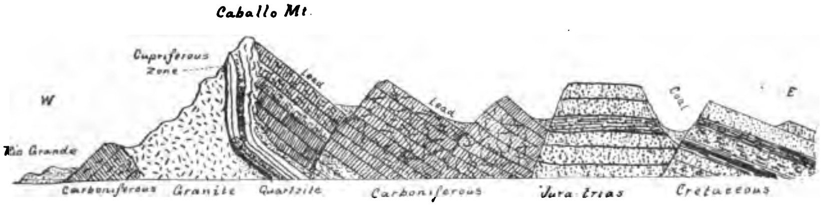
The region described extends many miles along the eastern slope of the San Andreas and similar conditions occur elsewhere. It is true that a considerable amount of fine copper ore occurs in these intersections and, with better means of access, they will no doubt be utilized, and it is also true that there may be found deeper workings where under different conditions of accumulation large bodies of good ore might occur, but the careful investor will avoid being deceived by the surface showing and will beware of too general application of the miner's notion that mineral must "go down."

The Caballo Mountains. Between the San Andreas and the Rio Grande is a large stretch of desert plain called the Jornada del Muerto which, from the lack of water, has long been a terror to the freighters and packers. Much of pioneer romance has been woven into stories of the Jornada and even since the railroad has bridged the gulf it is still unreclaimed. Toward the western border of the plain there is a series of basaltic cones from which there spread out over the plain larger or smaller sheets of lava, the most northern of which, at San Marcial, extends to the river. At this place the lava flows over a deposit of sand and stratified loam not unlike that west of Albuquerque. This series of basaltic flows is a continuation of that further north in the valley but the river at this point has been diverted to the west. The occasion for this diversion is apparently the elevation of a minor axis on the western border of the Jornada forming the San Cristobal and the Caballo mountains, in Sierra county.

Both these ranges rise quite abruptly from the eastern edge of the river valley to a variable hight. The Caballo range is the higher and is that with which we at present have to do and is mentioned in this connection to illustrate the modification of the same method of precipitation as that seen in the

San Andreas mountains. The western escarpment is for the most part very steep with evidence of very considerable metamorphism. The very axis of break in some places is preserved and affords very interesting illustrations of what can be done in the way of altering a limestone by the agency of mechanical friction and pressure without the presence of a source of igneous heat. So far as seen, there is no intrusive in this range but the displacement along the axis of uplift was very great and the area affected was quite narrow. The sequence of the strata seems to have been about the same as elsewhere in the valley although opportunity was lacking to make a sufficient examination of the lower as well as some of the higher strata at points where the absence of excessive metamorphism would admit of expecting organic remains. The fossils seen from the upper part are such as are found in the upper three hundred feet of the Carboniferous in Bernalillo Co., the abundance of Bryozoa being quite characteristic. Below the middle there are shaly beds in which are found the same facies which occurs in the lower parts of the series as exposed in Socorro and Bernalillo counties but the lower one hundred feet is so altered in all the places visited that it is impossible to deny the local belief that it contains some strata of an age earlier than the Carboniferous. However, it may be said that there is no evidence of unconformity in the series where undisturbed and there is nothing in the lithological character of this portion to dispose one to regard it as other than the sandy lower part of the Carboniferous as seen elsewhere in the valley. Such fossils as *Chonetes mesoloba*, *Spirifer opima*, *Martinia lineata*, *Aviculopecten carboniferus*, *Terebratula sp?* *Productus cora*, *P. nebrascensis*, in the lowest fossiliferous beds examined and certainly below the middle of the series permit us to expect that the lower parts will prove Carboniferous.

The foot of the western slope is granite, gneiss or schistose rock of a somewhat nondescript character, varying from place to place and much mingled locally along the axis, which, while in general trending north and south, has many local offsets and irregularities. Above the granite is a band of quartzyte as usual, the thickness being little more than twenty feet. At the contact with the limestone series is a coarser phase which from its position immediately above the impervious stratum formed by the granite, becomes the collector of the iron leeched from the rocks above, forming a band of variable width in which the sand grains are coated with iron oxide or replaced by it. In this case the collection is not so complete at this horizon as in the San Andreas by reason of the fact that the metamorphism of the sandy lower layers of the limestone has been so complete as to form water-bearing horizons above, and there has been a good deal of accumulation of iron in the same way at these higher levels. Along the axis of uplift the effect on the silicious materials has been very great, and there has been a thickening of these bands. The lime, on the other hand, has been abruptly turned on edge and the selvedge has been wedged in between the less altered lime and the granite till from a distance it appears in sections as though there had been an igneous intrusive thrust up at this point. Such an appearance is very deceptive in the section in the Palomas Gap canon and affords a most interesting geological object lesson. The general conditions are reproduced in the accompanying diagram.



The whole series is subject to the same system of fracture lines so much in evidence in the San Andreas and the collection of copper at the intersection of the veins with the iron band is similar, with this difference that, inasmuch as the iron is also to some extent precipitated in the lower members of the limestone series, the sulphides are also more extended in the vertical direction. This fact will also probably militate against the collection of very large bodies even at the intersection. The chemistry of the copper precipitation may well be a subject for speculation. That the iron is leeched from above can hardly be doubted and it is equally probable that the copper came up in some form from the depths along the fissures. It is obvious too that no considerable part of the copper has been precipitated in the granites or in part of the lime not within reach of the iron. It may be that the action of the air-bearing water near the surface tended to liberate sulphurous oxide and that an iron solution thus formed in the vicinity of the ore of iron produced the necessary conditions for precipitation, very much as they are supplied in certain leeching plants for the treatment of copper.

On the east side of the mountain near the axis, the lime is much tilted and is also disturbed in the direction of the strike of the range. In fact, the disturbances are of the most profound nature, yet the dip in general is sharply to the east and the limestone is minutely veiny. These veins are filled with fluorite, barite, quartz, and calcite and may also carry certain, or rather very uncertain, quantities of galena and, in some instances, wulfenite.. One or more faults parallel to the range repeat the strata toward the top of the formation in the successive foot-hills to the east and in these the metamorphism has been less intense and the veins are not quite so numerous. The larger ones cross the strata in, or nearly in, the plane of the dip and are sometimes quite large and in such cases often carry large quantities of galena in a barite gangue. In general, however, the veins give off "feathers" extending for fifty to seventy-five feet and these collateral veins are quite as likely to carry lead as the main vein so that the total amount of ore is difficult to recover. The commercial concentration of ores rich in heavy spar at a distance from water and fuel becomes an economic problem of as much difficulty as interest.

The time may doubtless come when nature will accomplish the concentration of the lead in much the same manner that it has done it in the Magdalena mountains and elsewhere where the sulphide, after having been altered to the sulphate is precipitated as a carbonate. That this process is in progress is shown by the fact that in the more exposed parts of the workings upon the veins the galena is quite extensively removed, and in parts not removed it is partly changed to sulphate. To determine in advance the secret chambers where the percolating waters will find the conditions for the reprecipitation of lead is beyond our power and this legacy to the future must be left to the future to recover.

Following the Carboniferous limestones is a series of very red sandstones and shales which is not shown in conformable relations to the lime but is seen in the ridges to the east of the latter lying with a much less sharp dip to the east. It may be that these beds, three or four hundred feet thick, are supported by Carboniferous strata but the contact is not exposed. No fossils except the trunks of trees have been found but from the lithological character, position and from general analogy they may be supposed to represent the so-called Juratriassic of other parts of the territory.

Following these red beds are the grey sand-stones and dark shales of the Cretaceous. It is impossible to determine the thickness of this formation but it is undobtedly extensive and, after forming the numerous ridges east of the red beds, the strata become less inclined and extend indefinitely to the east and are in places capped by the lava beds. Two rather small beds of coal are found in the lower part of the Cretacous as here exposed. The paleontological evidence is fairly complete but has not been sufficiently examined. Beds of Ostreas occur in the shales not far from the coal and in these the shells are well preserved.

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TABLES FOR THE DETERMINATION OF NEW MEXICO BEES.*

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The student should use E. T. Cresson's *Synopsis of the Families and Genera of Hymenoptera of America, North of Mexico*, (1887), to determine the genera. Thirteen genera given herein which are absent from Cresson's work may be determined as follows:

Hemihalictus, Ckll., is black, and resembles *Halictus* in structure, but has only two submarginal cells.

Parandrena, Rob., resembles *Andrena*, but has only two submarginal cells. It was formerly confounded with *Panurgus*.

Protandrena, Ckll., will run in Cresson's table to *Andrena*, but differs in having the marginal cell truncate at the end.

Halictoides, Nyl., has been confused with *Panurgus*, but it has a pointed marginal cell, whereas that of true *Panurgus* is truncate. The long tongue separates it from *Parandrena* and *Hemihalictus*.

Pseudopanurgus, Ckll., has been confused with *Calliopsis*, to which it will run in Cresson's table. The species are black, nearly naked, strongly punctured, with the wings fuliginous; marginal cell distinctly but obliquely truncate at tip; two submarginals, first recurrent nervure joining second submarginal cell no great distance before its middle, second recurrent joining it just before its tip; basal process of labrum large, subquadrate.

Panurginus, Nyl., includes part of what has been known as *Calliopsis*, namely the black species with no abdominal hair-bands, or light marks on the abdomen; and with yellow or yellowish-white on the faces of the males, with few exceptions.

Hesperapis, Ckll., has two submarginal cells, resembles *Phileremus*, but has a short dagger-like tongue. Mr. Ashmead refers it to *Rhophitosdes*, but the tongue is not at all as in that genus.

Neolarra, Ashm., is a Phileremine bee, easily known by its very small marginal cell.

Phileremulus, Ckll., is a minute bee resembling *Neolarra*, but with only one submarginal cell.

Ashmeadiella, Ckll., has been confused with *Heriades*, but is known by its clear wings, small or subobsdete stigma, first recurrent nervure reaching sub marginal cell further from the origin of the first transverso-cubital, and the abdomen of the males ending with four projections.

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Anthophorula, Ckll., is like a small *Podalirius*, but has only two submarginal cells. Tip of marginal cell away from costa.

Oxæa, Klug., differs from *Megacilissa* in that the first recurrent nervure unites with the second transverso-cubital instead of with the first. The labrum is very large, and the eyes in the males strongly converge above.

Exomalopsis, Spin., will run in Cresson's table to *Nomia*, but it is a long-tongued bee, in no way related to *Nomia*. The species are short and compact, shiny, with a very large loose scopa on the hind legs of the females.

Family. ANDRENIDÆ.

Subfamily. PROSOPIDINÆ.

COLLETES.

Large, *Andrena*-like species, with dark, often scarcely banded abdomen in the ♀ 1

Large, ♂ only known, black hairs on dorsum of thorax, very large punctures and five white hair-bands on abdomen. Length about 15 mm (Gila R., July.) . . . . *gilensis*, Ckll.

Smaller species, with banded abdomen, ... 3

1. No dark hairs on thorax. (Mesilla Valley, March.) *utilis*, Ckll. ♀.
With dark hairs on thorax 2

2. Tegulæ piceous, punctuation very strong and close, wings smoky. (Sacramento Mts., October.) . *bigeloviæ*, Ckll. ♀.
Tegulæ rufo-testaceous, punctuation not so close, wings perfectly clear. (Mesilla Valley, late summer.) . . . . . *armata*, Patton. ♀.

3. Distance between eyes and base of mandibles greater than breadth of latter; no black hairs on thorax . 4
Distance between eyes ead base of mandibles less than breadth of latter, ... 5

4. About 10 mm. long, pubescence of thorax tinged with ochreous. (Sacramento Mts. and Mesilla Valley, July.) . . . . . *wootoni*. Ckll. ♂.
About 7 mm. long, pubescence white or greyish-white, not at all ochreous. (Mesilla Valley, June.) . *daleæ*, Ckll, ♂.

5. Dorsum of thorax with some black hairs; length about 10 mm. (Mesilla Valley, May, at willow blossom.) . . . . . *texana*, Cress, ♀.
Thorax without black hair, ... 6

6. Pubescence of thorax short, the hairs stout, pubescent, moss-like; length about 11 mm. (Santa Fé, July.) . . . . . *aberrans*, Ckll., ♀.
Pubescence of thorax normal, ... 7

7. Flagellum ferruginous beneath, tarsi ferruginous; small species. (Mesilla Valley, May, at flowers of mesquite.) . . . . . *prosopidis*, Ckll., ♂.
Flagellum dark, ... 8

8. Vernal species, appearing at willow blossom in May; about 10 mm. long; stigma black. (Mesilla Valley.) . . . . *salicicola*, Ckll., ♀.
Summer and autumn species, ... 9
9. Punctuation of first abdominal segment feeble and sparse. 10.
Punctuation of first abdominal segment strong, . 12.
10. Species with cinereous pubescence, at most feebly yellowish, ... 11.
Small species with dense ochraceous pubescence; tarsi ferruginous. (Mesilla, end of August.) . *annæ*, Ckll., ♂.
11. Length about 8 mm., pubescence greyish-white. (Mesilla Valley, end of September.) . . *louisæ*, Ckll., ♂.
Length about 11 mm., pubescence of thorax with a delicate yellowish tinge. (White Sands, at flowers of *Bigelovia*, October.) . . . *gypsicolens*, Ckll., ♂.
12. Lateral faces of posterior truncation of thorax dull. . 13.
Lateral faces of posterior truncation shining or tuberculate, not minutely roughened. (Watrous, Las Vegas, Santa Fé, Mesilla Valley, &c.) . *americana*, Cress., ♂. ♀.
13. Larger; hind spur of hind tibia barely ciliate. (Ruidoso Creek, July.) . . . . . *kincaidii*, Ckll., ♀.
Smaller; hind spur of hind tibia pectinate. (Santa Fé, August.) . . . *chamæsarachæ*, Ckll., ♀.

Note.—For descriptions, see Ann. Mag. Nat. Hist., Jan., 1897. Some other species have been collected, but await study in the light of more abundant material.

PROSAPIS.

Males.

Upper part of lateral face-marks receding from orbital margin, . 1
Upper part of lateral face-marks continuous along orbital margin, . 4
1. Upper part of lateral face-marks arising away from the orbital margin, ... 2
Upper part of lateral face-marks touching orbital margin at the base, ... 3
2. Wings not brownish, face yellow. (Santa Fé.) . . . *rudbeckiæ*, Ckll. & Csd.
Wings tinged brownish, face yellowish-white. (Ruidoso Creek.) . . . *rudbeckiæ* race *ruidosensis*, Ckll.
3. Small species, with the upward extension of lateral face-marks itself little curved, and not greatly prolonged. (Mesilla Valley.) . . . . *mesillæ*, Ckll.
Larger species, with the upward extenston of lateral face-marks narrow and inclined to be curved; face-marks strongly yellow. (Ruidoso Creek.) . *tridentula*, Ckll.
4. Supraclypeal mark small and narrow; face much narrowed below. (Mesilla Valley.) . *asinina*, Ckll. & Casad.
Supraclypeal mark broad and short. (Ruidoso Creek.) . . , . . *wootoni*, Ckll.

Females.

First abdominal segment distinctly punctured; lateral face-marks shaped like feet on tiptoe, . . . *asinina*, Ckll. & Csd.

First abdominal segment indistinctly or not punctured; small species; clypeus with a light mark, ... *mesillæ*, Ckll.

Note,—Some other species have been collected, but not yet satisfactorily identified.

Subfamily. SPHECODINÆ.

SPHECODES.

Females.

Under 5 mm. long, abdomen long and narrow, orange. (Mesilla Valley.) . . . . . . *semicoloratus*, Ckll.

Larger, abdomen ferruginous, ... 1

1. Small, about 6 mm. long, abdomen black at the tip. (Mesilla Valley.) . . . *mandibularis*, Cresson.

Large, abdomen not black at tip, nervures and stigma very dark brown, ... 2

2. Mesothorax very strongly punctured, but the punctures separate, showing the shining surface between, . 3

Mesothorax not so punctured; very shining, with scattered punctures, ... 4

3. 8 to 8½ mm. long, mandibles simple, labrum not notched, head broad, flagellum ferruginous beneath towards end, wings dull hyaline, legs black, spurs of hind tibiæ ferruginous, abdomen punctured only on the basal parts of the second and following segments, except for a few small scattered inconspicuous punctures; basal enclosure of metathorax distinct, semi-lunar, very strongly irregularly wrinkled, so as to be cancellate. (Mesilla Park, N. M., at flowers of *Sophia*, April 12; also at El Paso, Texas, May 13.) . . *fortior*, Ckll. n. sp.

7 to 7½ mm. long, mandibles with a large tooth within; labrum scarcely produced, not notched; head broad, orbits more converging below than in *fortior*; metathoracic enclosure shorter, with radiating wrinkles, and feebler cross ones; otherwise much as in the last. (Mesilla Park, at flowers of *Sophia*, April 12, also at flowers of plum, March 23,) . . . *sophiæ*, Ckll., n. sp.

4. Considerably more robust than *mandibularis*; 6 mm. long, head large and broad, mandibles dentate within, labrum not produced or notched, flagellum wholly dark brown; mesothorax with very sparse punctures; metathoracic enclosure distinct, semilunar, strongly irregularly wrinkled; wings dusky hyaline; legs piceous, tarsi becoming ferruginous; abdomen sparsely punctured. (Santa Fé, on white umbelliferous flowers, July 16, 1894.) . . . . *asclepiadis*, Ckll., n. sp. (so-called because a pollen-body of *Asclepias* is adherent to the mouth of the type specimen.)

About 7 mm. long; resembles *asclepiadis*, but differs in the broader face, the flagellum more inclined to ferruginous beneath; the metathoracic enclosure with fewer, more radiating wrinkles; the upper port of the sides of the metathorax more bulging and less strongly sculptured; femora black, tibiæ and tarsi dull ferruginous, tibiæ with a suffused dark spot; mandibles simple; labrum inclined to be notched. (Mesilla Valley, at flowers of *Sophia*, April 12.) . *perlustrans*, Ckll., n. sp.

Subfamily. ANDRENINÆ.

HALICTUS.

Females.

Head and thorax black, abdomen rufous, . , . . 1

Head and thorax black, abdomen black with well formed hair-bands, 2

Head and thorax black, abdomen not distinctly banded, but often pubescent, ... 7

Head and thorax black, with a faint greenish tinge, or quite green, abdomen with well-formed hair-bands; size not over 7 mm., . 9

Head and thorax green or blue, abdomen without distinct hair-bauds, 10

1. Ocelli; extremely large, stigma honey-color, abomen apricot color. (Mesilla Valley.) . *texanus*, Cress, (*Parasphecodes.*)

Looks exactly like a *Sphecodes*; 7 mm. long, abdomen broad, dark apricot color, basal half of first segment black. Head and thorax strongly and very closely punctured, especially the head; head longitudinally oval, face much longer than broad, clypeus with large sparse punctures, scape thickly punctured, ocelli ordinary, antennæ short, flagellum except the first two joints ferruginous beneath; mesothorax with median and parapsidal grooves distinct; base of metathorax rugose, enclosure not defined, but bounded behind by a smooth shining area; tegulæ amber-color; wings hyaline, nervures and stigma dark sepia; legs dark, with light pubescence, first joint of hind tarsus with a brush of bright orange hair at its tip; abdomen with close small punctures, first segment nearly impunctate. (Santa Fè, Aug. 1, probably either on *Solidago* or *Clematis*, caught by either Myrtle Boyle or Veer Boyle.) . . . . . *ovaliceps*, Ckll., n. sp.

2. Cheeks produced to a prominent angle beneath; rather large species. (Mesilla Valley, Santa Fè. &c.) . *ligatus*, Say.

Cheeks not produced beneath, . . . 3

3. Stigma honey-color, or at least not dark brown, . 4

Stigma dark brown or black, ... 6

4. Tegulæ dark piceous, larger species, . . . 5

Tegulæ dark testaceous, smaller species, 8½ mm. long. (Mesilla Valley.) . . . . *amicus*, Ckll.

5. Wings tinged yellowish, nervures honey-color. (Ruidoso Creek, Bernalillo, Paraje.), . . *coriaceus*, Smith.

Wings clear, nervures fuscous, hair-bands of abdomen white. (Mesilla Valley.) . . *bardus*, Cresson.

6. Tegulæ testaceous; metathoracic enclosure truncate behind, with a sharp rim. (Mesilla Valley, Watrous.) . . . . *sisymbrii*, Ckll.

Tegulæ black; metathoracic enclosure semilunar. (Mesilla Valley.) . . . . *angustior*, Ckll.

7. Abdomen black, the segments not margined with testaceous; first segment impunctate; lateral white hair-patches present; stigma piceous. (Mesilla Valley, Roswell, Santa Fé.) . . . *pectoraloides*, Ckll.

Abdomen rather brownish, the hind margins of the segments more or less testaceous, first segment punctured, stigma honey color, ... 8

8. Flagellum more or less testaceous beneath, tarsi rufous, first segment of abdomen transversely striate. (Mesilla Valley, Santa Fé.) . . . *subobscurus*, Ckll.

Flagellum wholly dark, tarsi dark, first segment of abdomen not transversely striate, *amicus*, Ckll, (when worn.)

9. Mesothorax blue-black, scutellum and postcutellum dark greenish. (Santa Fé.) . . . . *tripartitus*, Ckll.

Mesothorax bronze-green or olive-green. (Mesilla Valley.) . . . . . *meliloti*, Ckll.

10. Very small; tegulæ punctured. (Mesilla.) *pseudotegularis*, Ckll.

Tegulæ not punctured, ... 11

11. Cheeks with a conspicuous tubercle beneath. Length about 6 mm., head and thorax dark bluish-green varying to olive green; abdomen very dark brown, with a distinct green lustre; hind margins of abdominal segments more or less testaceous; legs piceous; pubescence scanty, dirty white; abdomen pruinose-pubesent. Wings hyaline, stigma and nervures honey-color; tegulæ dark brown. Head very large, facial quadrangle about square; apical portion of clypeus purplish-back; front and sides of the face with small close punctures; mesothorax and scutellum with distinct but very sparse punctures; base of metathorax shining, obscurely roughened, with very faint longitudinal wrinkles towards the sides. Abdomen shining, hardly punctured. Allied to *H. connexus* and *H. cephalotes.* (Las Cruces, May, Miss Agnes Williams; Mesilla, April 27, at flowers of *Rosa blanda* in cultivation, C. M. Barber.) . . . . *oleosus*, Ckll., n. sp.

Cheeks not tuberculate, ... 12

12. Thorax blue; stigma pale yellowish, . . 13

Thorax green, ... 14

13. Mesothorax with very large and strong punctures. (Santa Fé.) . . . . . . *semicæruleus*, Ckll.

Thorax small, mesothorax shiny, hardly punctured. (Mesilla Valley.) . . . . . *semibrunneus*, Ckll.

14. Abdomen green like the head and thorax. (Mesilla Valley.) . . . . *pruinosus*, Rob.

Abdomen apricot color, often dark at the apex. This species, common in the Mesilla Valley, has formerly been recorded as *H. stultus*, but it differs from that, and resembles *H. nymphalis*, in having the mesothorax strongly and rather closely punctured. It differs from *nymphalis* in the bluer green of the head and thorax, but seems to be only a geographical race of that insect. *nymphalis*, Smith, race *mesillensis*, Ckll., n. race.

Abdomen black or piceous, ... 15

15. Stigma pale honey-color; metathorax dark blue; abdomen hoary. (Santa Fé.) . . *perdifficilis*, Ckll.

Stigma dark or light brown, when light a dilute sepia tint, ... 16

16. Tegulæ very dark; clypeus coppery or brassy, contrasting with the face. (Ruidoso Creek, Santa Fé, Mesilla Valley.) . . . . . *ruidosensis*, Ckll.

Tegulæ reddish-testaceous; face narrower. (Mesilla Valley.) . . . . . *ashmeadii*, Rob.

Note.—Several other green species of *Halictus* have been collected, but not yet sufficiently studied.

HEMIHALICTUS.

8 mm. long, black. (Lone mtn., at flowers of *Pyrrhopappus* early in the morning.) . . . . . . *lustrans*, Ckll.

AUGOCHLORA.

Entirely bluish-green, very brilliant; fourth ventral segment of male abdomen not emarginate. (Mesilla Valley, Organ Mts.) *neglectula*, Ckll.

AGAPOSTEMON.

Females.

Abdomen honey-color, ... *melliventris*, Cresson.

Abdomen green, like the head and thorax, ... I

I. Mesothorax with punctures of two sizes, *texanus*, Cresson.

Mesothorax roughened, . . . *radiatus*, Say.

These three are all found in the Mesilla Valley; *texanus* goes north to Embudo and Santa Fé; *melliventris* to Rincon and Vega S. José. The males of all have yellow abdomens banded with black.

ANDRENA.

Abdomen partly or wholly rufous, ... 1
Abdomen black or dark brown, at most pale-banded, . . 7
Abdomen blue. (Santa Fé, July) . . . . *cerasifolii*, Ckll.
1. Pubescence black. (Mesilla Valley, April.) . *prima*, Casad.
   Pubescence grey or fulvous, ... 2
2. Wings clear or almost so; abdomen not closely punctured. (Mesilla Valley, Paraje, April.) *sphecodina*, Casad. and Ckll.
   Wings clouded at apex at least, ... 3
3. Clypeus dark, at most with a yellow spot, . . 4
   Clypeus yellow, at least in the ♂, ... 5
4. First segment of abdomen very feebly and sparsely punctured. Mesilla Valley, April.) . . *jessicæ*, Ckll.
   First segment of abdomen strongly punctured. (Santa Fé, Aug.) . . . . . *argemonis*, Ckll.
5. Dorsum of thorax honey yellow. (Northern N. M.) *mellea*, Cress.
   Thorax entirely black, ... 6
6. Second segment of abdomen without a black band. (Mesilla Valley, Paraje, April.) . . *prunorum*, Ckll.
   Second segment of abdomen with a black band. (Mesilla Valley, April.) . . . . . *casadæ*, Ckll.
7. Pubescence black. (Mesilla Valley, April.) *nigerrima*, Casad.
   Pubescence at least partly pale, ... 8
8. Clypeus and part of sides of face yellow or white, 9
   Clypeus only yellow, ... 12
   Sides of face yellow, clypeus mostly dark. (Mesilla Valley, Oct.) . . . . . *pulchella*, Rob., ♀.
   Face all dark, ... 13
9. Wings dusky at apex, clypeus dark at sides, first two segments of abdomen with apical rufotestaceous bands. (Organ Mts., Sept.) . . *aliciarum*, Ckll., ♀.
   Wings clear, ... 10
10. Lower edge of clypeus broadly black, *pulchella*, Rob., ♂.
    Clypeus cream-color, edge not broadly black, . 11
11. Larger, flagellum dark, lateral face-marks pointed above. (Mesilla Valley, April.) *capricornis*, Csd. and Ckll., ♂.
    Smaller, flagellum ferruginous beneath. (Mesilla Valley, April.) . . . *primulifrons*, Casad., ♂.
12. Abdomen with orange color-bands. (Santa Fé.) . . . *aureocincta*, Ckll., ♂.
    Abdomen without color-bands, strongly punctured; wings dusky at apex. (Mesilla Valley, April.) *fracta*, Csd. and Ckll., ♂.

13. Pubescence of thorax bright ferruginous; wings very dark, especially at apex. (Embudo, Sept., at flowers of *Bigelovia.*) . . . . . ***vulpicolor***, Ckll., ♀.
Pubescence of thorax not ferruginous, or wings not very dark, ... 14

14. Hair at apex of abdomen black or fuscous, . 15
Hair at apex of abdomen pale or reddish, . 17

15. Abdomen shining, strongly punctured. (Paraje, April.) . . . ***pruniforis***, Ckll., ♀.
Abdomen microscopically tessellate, . . 16

16. Tarsi with fuscous hair. (Sacramento Mts., Aug.) . . . ***apacheorum***, Ckll., ♀.
Tarsi with pale hair. (Mesilla Valley, March, April.) . . ***electrica***, Csd. and Ckll., ♀.

17. Abdomen with continuous hair-bands, even on first segment 18
Abdomen with hair-bands more or less interrupted . 19
Abdomen without any distinct hair-bands or well-defined patches, ... 25

18. Pubescence all white. (Mesilla Valley, April.) . . ***electrica***, Csd. and Ckll., ♂.
Pubescence strongly yellowish. (Santa Fé, Aug.) ***mentzeliæ***, Ckll., ♀.

19. Head very large, keeled behind eyes. (Santa Fé Canon, 8000 ft., Aug.) ***platyparia***, Rob ♂. (var. ***occidentalis***, Ckll.)
Head ordinary, ... 20

20. Abdomen distinctly punctured, . . . 21
Abdomen more or less tessellate, hardly punctured, 22

21. Wings strongly clouded at apex, . ***fracta***, Csd. and Ckll., ♀.
Much smaller, wings perfectly clear, ***primulifrons*** Casad., ♀.

22. Length 15 mm. (Albuquerque, at sunflowers, Sept) . . . . ***helianthi***, Rob., ♀.
Length 12 mm. or less, ... 23

23. Tarsi ferruginous; small species. (Mesilla Valley, Paraje, April.), ... ***salicinella***, Ckll.
Tarsi dark, ... 24

24. Pubescence pale grey to white. (Mesilla Valley, March, April.), ... ***monilicornis***, Ckll., ♂.
Pubescence of thorax tinged with ochraceous; wings strongly yellowish. (Paraje, April.), ***subaustralis***, Ckll., ♀.

25. Abdomen minutely tessellate, . ***subaustralis***, Ckll., ♂.
Abdomen distinctly punctured. (Mesilla Valley, March.) . . . . . ***mesillæ***, Ckll., ♂.

Note.—The species of *Andrena* which fly in spring are to be taken in great number at the flowers of plum trees.

PARANDRENA.

Abdomen red, ... 1
Abdomen black, ... 2
1. Clypeus and sides of face yellow. (Mesilla Valley, Sept.) . . . . . *pectidis*, Ckll., ♀.
Face all black. (Mesilla Valley, April.), *andrenoides*, Cress. (var. *bicolor*, Rob.) ♀.
2. Clypeus and sides of face yellow, flagellum ferruginous beneath, ... *andrenoides*, Cress., ♂.
Face all black, ... 3
3. Length 7—7½ mm., legs wholly black, apex of wings slightly milky. (Mesilla Valley, Sept.), *oliviæ*, Ckll., ♂.
Length 8—9½ mm., tarsi of ♂ wholly pale ferruginous. (Mesilla Valley, Sept.), . . . *rhodocerata*, Ckll.

Note.—P. andrenoides is the type of the genus; the others are not strictly congeneric, and are placed here provisionally. The last two are referred by Mr. Ashmead to *Rhophitoides*.

NOMIA.

Abdomen ferruginous, or ferruginous and black. (Albuquerque, Mesilla Valley.), . . . *nevadensis*, Cress.
Abdomen black, apical margins of segments not greenish; ♀ like an *Andrena*. (Albuquerque, Mesilla Valley.), ... *persimilis*, Ckll.
Abdomen black, apical margins of segments light green or greenish-white, ... 1
1. Size large, 17 mm. long or over. (Northern N. M.) *nortoni*, Cress.
Size smaller, not 15 mm. long. (Santa Fé, Mesilla Valley, Rincon, etc.), ... *foxii*, Dalla Torre.

EUNOMIA.

Pubescence cinereous, with a yellowish tinge. (Mesilla Valley.), ... *heteropoda*, Say.
Pubescence dull yellowish; tibiæ and tarsi in ♀ more or less fulvous. (Northern N. M.), ... *apacha*, Cress.
Pubescence (♂) brownish-ochraceous, legs shining; ♀ entirely black or brown-black, ... *marginipennis*, Cress.

Note.—E. heteropoda ♂ was taken at Mesilla Park, Sept. 17, in a sandy place. The other two species I have not seen.

Subfamily. PANURGINÆ.

PROTANDRENA.

Large species, 10 mm. long or over, ... 1
Smaller species, less than 10 mm. long, ... 2
1. Stigma ferruginous. (Mesilla Valley.) *mexicanorum*, Ckll.
Stigma very dark brown. (Santa Fé, Albuquerque.), . . *mexicanorum*, race *asclepiadis*, Ckll.
2. Tarsi piceous in ♀. (Albuquerque.), . *trifoliata*, Ckll.
Tarsi rufous in ♀, yellowish-white in ♂. (Mesilla Valley.), ... *heteromorpha*, Ckll.

HALICTOIDES.

Very small, about 6 mm. long. (Organ mts., at *Gymnolomia* fls.), ... *tinsleyi*, Ckll., ♀.

Larger, 8 mm. or over; ♀ with hind margins of abdominal segments testaceous. (Santa Fé, Rinconada, Mesilla Valley, at fls. of *Helianthus* and *Verbesina*, Aug. to Oct.), . . *marginatus*, Cress.

Note.—H. tinsleyi is perhaps not strictly congeneric with *marginatus*.

PSEUDOPANURGUS.

About 6½ mm. long, a shining boss adjacent to the top of each eye; clypeus and lateral face-marks in ♂ yellow. (Albuquerque, Mesilla Valley, Aug., Sept., at *Bigelovia* fls.) . . *rugosus*, Rob.

Larger, without the shining boss at the summit of the eyes. (Mesilla Valley, at *Helianthus* fls.) . . . . *æthiops*, Cress.

Note.—The first species is my *P. fraterculus;* Robertson says it is his *rugosus*, but I could not so determine from his description.

PANURGINUS.

Face with light markings, ... 1

Face without light markings, ... 7

1. Females, face with only a kidney-shaped yellow mark. (Mesilla Valley.) . . . *renimaculatus*, Ckll.

Males, ... 2

2. Pale color of face confined to clypeus; first recurrent nervure not uniting with second transverso-cubital. (Organ Mts.) . . . . . . *townsendi*, Ckll.

Pale color of face not confined to clypeus, . . 3

3. Pale color confined to clypeus and lateral marks, . . 4

Pale color not confined to clypeus and lateral marks, . 6

4. Face-marks yellowish-white, face with long white hair. (Albuquerque.) . . . . . *hirsutifrons*, Ckll.

Face-marks lemon yellow, face little or not hairy, . 5

5. Front hairy; lateral face-marks extending some distance above level of top of clypeus. (Santa Fé at fls. of *Rudbeckia*.) . . . . . *albitarsis*, Cress., ♂.

Front not hairy; lateral face-marks hardly extending above level of top of clypeus. Length 5 mm., flagellum ferruginous beneath, except at base: eyes dark sage green; wings very faintly dusky, nervures and stigma dark brown. Tubercles with a testaceous spot. (Santa Fé, Aug. 5.) . . *pauper*, Cress., var. *flavotinctus*, n. var.

6. Scape wholly black. (Santa Fé.) . . . . . . *boylei*, Ckll. (? var. of *ornatipes* Cress.)

7. Flagellum dark; nervures and stigma testaceous, ... *albitarsis*, Cress., ♀.

Flagellum largely testaceous beneath; very smooth species 8 mm. long. (Las Cruces, at fls. of *Helianthus*.) . . . . *perlævis*, Ckll., ♀.

CALLIOPSIS.

Abdomen bright ferruginous. (Mesilla Valley, at fls. of *Sphæralcea*.) . . . . . *semirufus*, Ckll.

Abdomen dark, with or without light markings, ... 1

1. Face with light markings, ... 2

Face without light markings, abdomen with white bands. (Mesilla Valley.) . . . *meliloti*, Ckll., . ♀

2. Abdomen with color-bands or spots, . . . 3

Abdomen without bands or spots, ... 5

3. Clypeus only partly light, ... 4

Clypeus all light except the dots and edge, face densely bearded with white hair, . . *australior*, Ckll., ♂.

4. Band on third abdominal segment always interrupted, 5th segment black, with neither band nor spots. (Albuquerque, Mesilla, at *Cleome* fls., &c.) . *australior*, Ckll., ♀.

Band on third segment usually entire, 5th segment largely pale. (Santa Fè, at fls. of *Cleome*.) . *scitulus*, Cress. ♀.

5. Females, ... 6

Males, ... 7

6. Clypeus yellow except two cuneiform black marks; lateral face-marks going nearly to summit of eyes. (Santa Fè, Embudo, Organ Mts.) . . *coloradensis*, Cress.

Clypeus with a longitudinal yellow mark or band on disk. (Santa Fé) . . . . *rhodophilus*, Ckll.

7. Legs mostly black; a black spot at tip of wing. (Mesilla Valley, at fls. of *Sphæralcea*,) . . *subalpinus*, Ckll.

Legs mostly yellow; no black spot at tip of wing. (Santa Fé, at fls. of *Sphæralcea*.) . . *rhodophilus*, Ckll.

Femora black, pale orange at apex; tibiæ all pale orange in front, largely black behind, tarsi yellow, the small joints becoming fuscous. Differs from *rhodophilus* in being larger and more pubescent; face-marks cream-color, lateral marks ending in a point above; eyes light chocolate color; no black spot at tip of wing. (Mesilla, Aug. 21.) . *flavifrons*, Smith, race *coloratipes*, n. race.

PERDITA.

Yellow, without conspicuous markings, ... 1

Yellow or orange, with conspicuous dark markings, . . . 2

Head and thorax dark, with or without light markings, . . 3

1. 8 mm. long, mesothorax pubescent, pleura with a black patch. (Mesilla Valley, Sept., at fls. of *Verbesina*.) . . . . . . *beata*, Ckll.

Not over 6 mm. long, pale yellow, pleura with a black patch. (Near Tularosa, Aug., at fls. of *Mentzelia*.) . . . . . . *wootonæ*, Ckll.

About the size of *wootonæ*, but very bright yellow, pleura without a black patch. (Mesilla Valley, Sept., at fls. of *Bigelovia*, ... *luteola*, Ckll.

About 4 mm. long, head very large, cheeks armed with a stout spine. (San Marcial, June, at fls. of *Larrea.*) . . . . *larreæ,* Ckll., ♂.

Like *larreæ,* but head not nearly so large. (Mesilla Valley, at fls. of *Larrea.*) . . *larreæ,* var. *modesta,* Ckll., ♂.

2. Extremely small, cheeks armed, mesothorax mostly green. (San Marcial, at fls. of *Larrea.*) . *marcialis,* Ckll., ♂.

Not so small, vertex with a black band from eye to eye, thorax with black markings, abdomen with distinct bands. (Mesilla Valley, at fls. of Mesquite.) . . . . *punctosignata,* Ckll., ♂.

Much like the last, but easily known by stigma, white basally, otherwise occupied by a large black spot. (Mesilla Valley, at willow.) , . . *maculigera,* Ckll.

3. Abdomen orange, or orange brown, or pale brown, or ferruginous; not banded, unless at base, . . 4

Abdomen dark brown or black, or spotted, or banded, 11

4. Head large, abdomen short and broad, ferruginous, marginal cell obliquely truncate, mandibles bidentate; head and thorax dark green. (Mesilla Valley, at fls. of *Sphæralcea.*) . . . . . . *latior,* Ckll., ♂.

Not so, ... 5

5. Cheeks toothed beneath, legs entirely yellow. (Albuquerque, Mesilla Valley.) . *pallidior,* var. *pulchrior,* Ckll., ♂.

Cheeks unarmed, ... 6

6. Face all dark, nervures colorless, abdomen orange. (Mesilla Valley, at fls. of *Bigelovia, Solidago* and *Gutierrezia.*) . . . . . . *semicrocea,* Ckll., ♀.

Face partly pale, ... 7

7. The pale color confined to clypeus and triangular marks at sides of face. (Albuquerque, Santa Fé, at fls. of *Chamæsaracha.*) . . . *chamæsarachæ,* Ckll., ♀.

Face all light below antennæ, ... 8

8. Vertex smooth and shining, ... 9

Vertex distinctly granular, ... 10

9. Abdomen orange, head and thorax dark olive green, ... *semicrocea,* Ckll., ♂.

Abdomen light brown, head and thorax dark blue. (Mesilla, at fls. of *Sida.*) . . . . . *sidæ,* Ckll., ♂.

10. Face very bright yellow, head and thorax green. (Embudo, at fls. of *Bigelovia.*) . . *rhodura,* Ckll., ♂.

Face yellowish-white, head and thorax dark blue, ... *chamæsarachæ,* Ckll., ♂.

11. Clypeus entirely dark (upper edge whitish in *sidæ* ♀,) . 12

Clypeus not entirely dark, ... 22

12. Abdomen piceous with yellow spots or dots, legs with yellow markings. (Santa Fé, July.) . *sexmaculata,* Ckll. ♀.

Abdomen not spotted, ... 13

13. Abdomen black, with pale yellowish bands, or yellow, with dark bands, ... 14

Abdomen dark brown, with a short white band on second segment; size very small. (Mesilla Valley, at fls. of *Cladothrix.*) . . . *cladothricis*, Ckll., ♀.

Abdomen not banded, ... 18

14. Stigma brownish, mesothorax hairy; length 7 mm. or over, ... 15

Stigma pallid; length not over 6 mm., - . . . 16

15. Nervures almost colorless. (Mesilla Valley, at fls. of *Sphæralcea.*) . . . *sphæralceæ*, Ckll., ♀.

Nervures dark brown. (Santa Fé, at fls. of *Sphæralcea.*) . . *sphæralceæ* race *alticola*, Ckll., ♀.

16. Face with pale lateral marks, . . . 17

Face all dark; abdomen brown-black, with three dull yellow bands terminating abruptly before reaching the lateral margin. (Embudo, Sept., at fls. of *Bigelovia.*) . . . . *subfasciata*, Ckll., ♀.

17. Anterior femora mostly black, abdomen with heavy dark bands. (Santa Fé, at fls. of *Mentzelia.*) . . . . *mentzeliæ*, Ckll., ♀.

Anterior femora entirely pale, abdomen with evanescent bands. (Albuquerque, Mesilla Valley, at fls. of *Mentzelia.*) . . . . . *pallidior*, Ckll., ♀.

18. Head and thorax black, size small. (Organ Mts., at fls. of *Pectis.*) . . . . *solitaria*, Ckll., ♀.

Thorax black except the green metathorax; head green, front æneous. (Mesilla Valley, at fls. of *Bigelovia*) . . . . *æneifrons*, Ckll., ♀.

Thorax black except the blue metathorax; head blue; a yellow spot on each side of the clypeus. (San Marcial, at fls. of *Larrea.*) . . . *semicærulea*, Ckll., ♀.

Head and thorax green, or greenish-blue, . 19

19. Males, 5½ mm. long, clypeus black, supraclypeal area æneous; hind margins of abdominal segments rather broadly hyaline. (Organ Mts., at fls. of *Verbesina*) . . . . . *chrysophila*, Ckll.

Females, ... 20

20. Abdomen broad, mandibles bidentate, marginal cell obliquely truncate, . . . *latior*, Ckll., ♀.

Not so, ... 21

21. Small, about 4½ mm. long, nervures brown. (Mesilla Valley, at fls. of *Bigelovia* and *Gutierrezia.*) *phymatæ*, Ckll.

A little larger, nervures white, upper edge of clypeus whitish, ... *sidæ*, Ckll, ♀.

Over 6 mm. long, nervures nearly colorless, . . *verbesinæ*, var. *nigrior*, Ckll.

22. Face below level of antennæ all yellow or white, except clypeal dots in some. (Males) . . 23
Face below level of antennæ not all pale, . 43

23. Face below antennæ white, . . . 24
Face below antennæ yellow, ... 26

24. Abdomen oval, reddish brown, suffused with darker; clypeus tinged with yellow; front nude and very shiny. (Las Cruces, Aug.) . . *crassiceps*, Ckll. var.
Abdomen yellowish-white, banded; face below antennæ pellucid white; first four legs all dull white except a dark streak on middle tibiæ. (Mesilla Valley, at fls. of *Bigelovia*.) . . . . . *pellucida*, Ckll.
Last three segments of abdomen rufous, the others banded. (Albuquerque, La Tenaja, at fls. of *Croton*.) *crotonis*, Ckll.
Abdomen dark brown with white markings, . 25

25. Abdomen with about 6 white marks, or fewer yellowish spots. (Mesilla Valley, at fls. of *Pectis*.) *pectidis*, Ckll.
Abdomen with two more or less developed white bands, ... *cladothricis*, Ckll.

26. Anterior and middle femora marked with black, . 27
Anterior femora all yellow, the four anterior tibiæ not all yellow, ... 33
First four legs all yellow, or at least not marked with black or brown, ... 34

27. Nervures pallid, ... 28
Nervures dark, ... 29

28. Stigma margined with brown; venter of abdomen immaculate in middle, . . . *sphæralceæ*, Ckll.
Stigma pale orange, not margined with brown; venter with a series of large black patches down the middle. (Mesilla Valley, at fls. of *Verbesina*.) *perpulchra*, Ckll.

29. Face nearly bare, bright yellow below antennæ, . 30
Face and disc of mesothorax hairy, . . 32

30. Very small, abdomen yellow with pale suffused brown bands. (Mesilla Valley, at fls. of *Pectis*.) *biparticeps*, Ckll.
Abdomen dark with clean-cut interrupted yellow bands, 31

31. Small, 4½ mm. long. (Mesilla Valley, May, at fls. of *Erigeron*.) . . . . . *erigeronis*, Ckll.
Larger. (Embudo, Sept., at fls. of *Bigelovia*) *affinis*, Cress.

32. Head broader than long; distal band on 2nd abdominal segment broadly continued to lateral margin, *sphæralceæ* race *alticola*, Ckll.
Head round: distal band of 2nd abdominal segment failing some distance before lateral margin. (Mesilla Valley, May.) . . . . . *hirsuta*, Ckll.

33. Face not all yellow up to middle ocellus. (Mesilla Valley, at fls. of *Bigelovia*.) . . . . *maculipes*, Ckll.

34. Legs entirely orange-rufous, abdomen black. (Santa Fé, June.) . . . . . . *foxi*, Ckll.
Legs not orange-rufous, abdomen banded, . 35
35. The yellow entending above antennæ in median line, 36
The yellow not extending above antennæ in median line, 41
36. The yellow extending above across the face, . 37
The yellow extending above only at sides and middle line, 39
37. Larger, about 5 mm. long, face-marking resembling *gutierreziæ*. (Albuquerque, Mesilla Valley, at fls. of *Bigelovia*.) . . . . . . *bigeloviæ*, Ckll.
Smaller, about 4 mm. long, ... 38
38. Face yellow up to anterior ocellus. (Mesilla Valley, April.) . . . *martini*, Ckll.
Face not yellow up to anterior ocellus. (Albuquerque, at fls. of *Gutierrezia*.) . . . *gutierreziæ*, Ckll.
39. Upward extension of yellow in median line linear; nervures colorless. (Organ Mts., at fls. of *Mentzelia*.) . . . *mentzeliarum*, Ckll.
Upward extension of yellow in median line shaped like a spear-head; nervures brown. (Mesilla Vallew, at fls. of willow.) . . . . . . *salicis*, Ckll.
Upward extension of yellow in median line broader, 40
40. Incusion of blue downward terminating at a right angle; pleura dark. (Mesilla Valley, at fls. of *Bigelovia*.) *nitidella*, Ckll.
Incursion of blue terminating at an acute angle; pleura largely yellow. (Mesilla Valley, at fls. of mesquite.) . . . . . *exclamans*, Ckll.
41. Cheeks armed, abdomen heavily banded, . *mentzeliæ*, Ckll.
Cheeks unarmed, ... 42
42. Abdomen not heavily marked, . . *pallidior*, Ckll.
Abdomen heavily marked with broad black bands. (Embudo, White Sands, at fls. of *Bigelovia*.) *townsendi*, Ckll.
43. The pale color confined to clypeus and sides of face, 44
The pale color not confined to clypeus and sides of face, 70
44. Abdomen dark, not banded, or the bands discontinuous, 45
Abdomen with continuous bands, . . 60
45. Larger species, length over 6 mm. . . . 46
Smaller species, 6 mm. or less, . . . 50
46. Mesothorax practically nude, ... 47
Mesothorax hairy, ... 48
47. Abdomen dark brown without pale marks, *nuda*, Ckll , ♀.
Abdomen with creamy-white marks. (Mesilla Valley, at fls. of *Senecio*.) . . . *senecionis*, Ckll., ♀.
48. Female: abdomen more or less spotted. (Mesilla Valley, at fls. of *Verbesina*.) . . . *verbesinæ*, Ckll.
Males, ... 49

49. Head and thorax brassy green. (Santa Fé, Socorro, at fls. of *Lepachys*.) . . . . . *lepachidis*, Ckll.

Head and thorax rather bluish green. (at fls. of *Helianthus*.) . . . . . . *albipennis*, Cress.

50. Abdomen without distinct light markings, . . 51

Abdomen with yellow or white markings, . 56

51. Pale face-marks reduced to a spot on clypeus; nervures brown, ... *phymatæ*, Ckll., var. ♀.

Pale face-marks not so reduced, lateral marks present; nervures pallid, ... 52

52. Clypeus with two large dark patches on hind margin; mesothorax very hairy. (Mesilla Valley, at fls. of *Aster*.) . . . . . *asteris*, Ckll., ♀.

Clypeus pale except the usual dots, . . 53

53. Anterior tibiæ black in front; face extremely hairy. (Mesilla Valley, at fls. of *Verbesina*.) *albovittata*, Ckll., ♂.

Anterior tibiæ yellow or rufotestaceous in front, . 54

54. Marginal cell with the substigmatal portion very much larger than than the poststigmatal; size very small. (San Marcial, at fls. of *Larrea*.) . *larrearum*, Ckll., ♀.

Marginal cell ordinary, ... 55

55. Larger (4½ mm.), face less hairy, lateral face-marks shaped like the mainsail of a schooner. (Mesilla Valley, at fls. of *Verbesina*, Sept.) . . *vagans*, Ckll., ♂.

Smaller (4 mm.), hairy, lateral face-marks triangular. (Mesilla Valley, at fls. of *Chrysopsis*.) *vespertilio*, Ckll., ♂.

56. Abdomen with cream-colored bands, interrupted sublaterally, ... 57

Abdomen with 6 or 8 white marks, . . 58

Abdomen with yellowish marks; mesothorax dull, granulated, ... *affinis*, Cress., ♂.

57. Only the broad lower margin of clypeus white. (Mesilla Valley.) (var. *chrysoceras* differs from *callicerata* principally in its large, subquadrate head.) *callicerata* var. *chrysoceras*, Ckll., ♂.

Clypeus entirely cream-color, except the usual black specks, ... *callicerata*, Ckll., ♀.

58. Marks on abdomen straight; clypeus white; length about 5 mm. (Mesilla, at fls. of *Aster spinosus*.) *ignota*, Ckll., ♀.

Marks on abdomen oblique, . . . 59

59. Mesothorax shiny; clypeus dark with a light spot; face-markings white, . . . *pectidis*, Ckll., ♀.

Mesothorax dull; clypeus light with dark spots or bars; face-markings yellowish. (Mesilla Valley, at fls. of *Bigelovia*, etc.) . . . *fallax*, Ckll., ♀.

60. Large species, length over 6 mm., . . 61

Smaller species, 6 mm. or less, . . . 64

61. Males, abdominal bands narrow, inconspicuous, dull yellow, emarginate at sides, ... 62
Females, bands conspicuons, ... 63

62. Front comparative shining, flagellum blackish. (Mesilla Valley.) . . . *albipennis*, race *helianthi*, Ckll
Front dull, flagellum orange, . . *verbesinæ*, Ckll.

63. Abdomen with, white black bands, clypeus white, with two black dots, ... *perpulchra*, Ckll.
Abdomen dark, with yellow bands, . *albipennis*, Cress.

64. Clypeus hairy, face-marks and abdominal bands white or cream color, ... 65
Not so, ... , . 66

65. Legs black, ... *albovittata*, Ckll., ♀.
Legs black and yellow. (Mesilla Valley, at fls. of *Baileya*). . . . . . *callicerata*, Ckll, ♂.

66. Yellow at sides of face extending above level of insertion of antennæ; size very small. (Albuquerque, Mesilla Valley, at fls. of *Gutierrezia* and *Bigelovia*.) . *austini*, Ckll., ♂.
Yellow or whitish at sides of face only extending to level of insertion of antennæ; size not so small, . 67

67. Abdomen dark, with light bands, . *bigeloviæ*, Ckll., ♀.
Abdomen light, with dark banks, . . . 68

68. Nervures colorless. (At fls. of *Mentzelia*.) *mentzeliarum*, Ckll., ♀.
Nervures dark brown, ... 69

69. Mesothorax very shiny, dark blue-green,. . *nitidella*, Ckll., ♀.
Mesothorax granular, dark olive-green: end of abdomen brownish-orange, . . . *rhodura*, Ckll., ♀.

70. Dog-ear marks absent, ... 71
Dog-ear marks present, or at least represented by dots, 77

71. Abdomen with the last two segments bright rufous, the others white, with black bands, . *crotonis*, Ckll., ♀.
Not so, ... 72

72. Bands of abdomen at least mostly entire, . . 73
Bands of abdomen all interupted, . *affinis*, Cress, ♀, var.
Abdomen dark without bands, . . . 76

73. Stigma solid dark brown or black. (Mesilla Valley, May, at fls. of willow.) . . . *numerata*, Ckll., ♀.
Stigma hyaline, at least centrally, . . . 74

74. Lateral face-marks truncate above, with a linear extension beyond the truncation; femora entirely yellow; length about 7½ mm., . . . *townsendi*, Ckll., ♀.
Lateral face-marks obliquely truncate above; femora partly black, ... *bigeloviæ*, Ckll., ♀, var.
Lateral face-marks coming to a point above, . . 75

75. About 6 mm. long, resembling *townsendi*; ventral surface of abdomen pale yellow; face-marks yellow. (Sacramento Mts., at fls. of *Bigelovia*.) . *stottleri*, Ckll., ♀.

Face-markings pallid. (Albuquerque, Santa Fé, &c., abundant at fls. of *Cleome.*) . . *zebrata*, Cress, ♀.

76. Head large, quadrate, face very hairy. (Mesilla Valley.) . . *albovittata* var. *laticeps*, Ckll., ♂.

Head ordinary, face not so hairy, . *asteris*, Ckll., ♀, var.

77. Abdomen black or dark brown, without pale marks, . 78

Abdomen not banded, but with yellow marks, which are small and straight. (Mesilla Valley, at fls. of *Gutierrezia.*) . . . . . . *tarda*, Ckll., ♂.

Abdomen distinctly banded, ... 79

78. Cheeks armed, head large; clypeus with a narrow median line and broad anterior border yellow. (Mesilla Valley, at fls. of *Solidago.*) . . *grandiceps*, Ckll., ♂.

Cheeks unarmed, clypeus all pale except the usual dots. (Albuquerque.) . . . . *crassiceps*, Ckll., ♂.

79. Males, ... 80

Females, ... 81

80. Mesothorax granular; face-markings deep yellow, ... *sphæralceæ*, var.

Mesothorax smooth and shining, . . *zebrata*, Cress.

81. Nervures colorless. (At fls. of willow.) . . *salicis*, Ckll.

Nervures dark. (At fls. of mesquite.) . *exclamans*, Ckll.

Subfamily. NOMADINÆ.

NOMADA.

Entirely ferruginous, without light markings. (Mesilla Valley, at fls. of plum.) . . , . *americana*, Kirby, race *incerta*, Cress.

Ferruginous, with cream-colored markings; sides of face cream-color, but clypeus ferruginous. (Mesilla Valley, at fls. of *Gutierrezia.*) . . . . *gutierreziæ*, Ckll.

Head and thorax black, with yellow markings; abdomen banded; legs ferruginous. (Mesilla Valley, Santa Fé.) . . *modesta*, Cress.

Head and thorax black, abdomen black and rufous . . . 1

1. Clypeus reddish; basal part of first abdominal segment black; legs rufous. (Mesilla Valley, July.) . *pennigera*, Ckll.

Clypeus black; first abdominal segment entirely red; legs black. (Mesilla, July 21, at fls. of *Sida hederacea.*) . . *pennigera*, var. *sidæfloris*, n. var.

Family. APIDÆ.

Subfamily. PHILEREMINÆ.

HESPERAPIS.

About 6 mm. long; head and thorax black, with short pubescence; abdomen dull ferruginous, with light hair-bands; hind tibiæ and tarsi with very short white tomentum, and long black bristles. (Mesilla Park, April, C. M. Barber.) . . *elegantula*, Ckll.

NEOLARRA.

6 to 7 mm. long, form elongate, abdomen pointed; head and thorax black, abdomen and legs rufous. (Mesilla Valley, Sept., at fls. of *Verbesina.*) . . . . *verbesinæ*, Ckll.

Much smaller, hardly 4 mm ; abdomen shorter, not so brightly colored. (Mesilla Park, May 7, at fls. of *Dithyræa wislizenii.*) . *pruinosa*, Ashm.

PHILEREMULUS.

♂ 3½, ♀ 3 mm. long, ♂ dull black, ♀ with rufous abdomen. (Mesilla Valley, Sept.) . . . . . . *vigilans*, Ckll.

♀ 3½ mm. long, head a little larger, mandibles more rufous, clypeus not white with scales, last joint of antennæ obliquely truncate. (Santa Fé. August.) . . . . . . *nanus*, Ckll.

PHILEREMUS.

Less than 6 mm. long, abdomen orange and black, with spots of white pubescence. (Santa Fé, August,) . . . . *pulchellus*, Ckll.

Length 6 mm. or over, abdomen with continuous white bands of pubescence. 1

1. Length 6 mm., abdomen subglobose, with no red tinge. (Mesilla Valley, April.) . . . *mesillæ*, Ckll., ♂.

Length 9 to 10 mm., abdomen elongate.pyriform, tinged with dull red; legs entirely ferruginous; scutellum with an apical spine. (Mesilla Park, April, at fls. of *Sophia;* Ckll. and Miss J. E. Casad,) . . . . *productus*, Cress., var. *subruber*, n. var. ♀.

Subfamily. MELECTINÆ.

EPEOLUS.

Abdominal bands all interrupted in the middle, the ends on each side of the interruption swollen. (Deming, Mesilla Valley.) . *verbesinæ*, Ckll.

Abdominal bands entire, or some slightly divided, but then the adjacent ends are not swollen, ... 1

1. Small compact species, less than 9 mm. long, tibial spurs ferruginous. (Mesilla Valley.) . . . *compactus*, Cress.

Larger, 10 mm. or over. 2

2. Legs red, ... 3

Legs black ; tegulæ piceous, ... 6

3. Tegulæ black or fuscous ; spurs of four hind tibiæ black, . 4

Tegulæ apricot-color or rufotestaceous, . . . 5

4. Length 12 mm. (Mesilla, June.) . *texanus*, Cress., ♂.

Length 14 mm,, differs from *remigatus* by the red legs; black patch on middle of first abdominal segment nearly an equilateral triangle, but the corners rounded; apex of abdomen not truncate. (Mesilla, June.) . . . . . . *texanus*, Cress, ♀.

5. Black space in middle of first abdominal segment semilunar or broadly triangular. (Mesilla Valley.) . *lunatus*, Say.
   Black space in middle of first abdominal segment a transverse band, not triangular. (Santa Fé, Albuquerque, Mesilla Valley.) . . . . *occidentalis*, Cress.
6. Clypeus with numerous minute punctures, and sparse large ones, ... 7
   Clypeus strongly, very densely, uniformly punctured, . . 8
7. Apex of ♀ abdomen subtruncate, last ventral segment produced and curved downwards, fifth abdominal segment without lateral patches of light pubescence, ... *concavus*, Cress.
   Apex of ♀ abdomen not at all truncate; last ventral segment broad, not produced beyond last dorsal; fifth abdominal segment with a patch of light pubescence on each side. (Albuquerque.) . . *robustus*, Cress.
8. Antennæ wholly dark. (Mesilla, Aug. 14, at fls. of *Helianthus ciliaris*.) . . *texanus* var. *nigripes*, n. var. ♂.

Note.—What has been regarded as *E. remigatus*, Fabr., in New Mexico seems to be *robustus*. It is possible that the species recorded by Cresson as taken by Lewis many years ago, was true *remigatus*.

ERICROCIS.

Appearance and ornaments much like *Epeolus;* the yellowish-white hair-bands of abdomen, felted as in *Epeolus*, all broadly interrupted; third submarginal cell in ♂ about twice as broad as second, in ♀ hardly broader than second. (Mesilla Park, April 29, 1898, the sexes together on flowers of *Cædalpinia falcaria* var. *stricta*, C. M. Barber.) . . . . *lata*, Cress.

Note.—Although there is a striking difference in the venation of the two sexes, they certainly belong together. A single ♂ of *E. lata* was taken by Mr. A. P. Morse near Little Mountain, Mesilla Valley, July 1, 1897.

MELECTA.

Abdomen with brown spots and a brown patch on a white ground, the white due to pubescence; size small; flagellum very stout. (Mesilla Valley.) . . . . . . *maculata*, Cress.

Abdomen black, with clean-cut light bands, interrupted medially, 1

1. Larger, the bands fulvous. (Vega San José, Continental Divide.) . . . . . *interrupta*, Cress.
   Smaller, the bands white. (Santa Fé, Mesilla Valley.) . . . . *miranda*, Fox.

BOMBOMELECTA.

Larger, pubescence of thorax and first abdominal segment bright orange-fulvous. (Mesilla Valley, at fls. of *Lycium*.) . . *thoracica*, Cress., var. *fulvida*, Cress.

Smaller, pubescence of thorax and first abdominal segment greyish-white. (Mesilla Valley, at fls. of plum.) . . *alfredi*, Ckll.

Subfamily. CŒLIOXYNÆ.

CŒLIOXYS.

Legs and first abdominal segment red; middle of second to fifth segments smooth and impunctate, or with a few scattered punctures. (Deming.) . . . . *menthæ*, Ckll.

Legs red; first abdominal segment black like the rest; middle of segments punctured. (Mesilla Valley.) . . . *octodentata*, Say.

Legs black; tarsi rufous. (Gila R.) . . . *gilensis*, n. sp. ♂.

Note.—*C. gilensis* was found in numbers by Prof. Townsend on the West Fork of the Gila R., July 16. Mr. Fox compared it with Cresson's types, and returned it marked, "near *mæsta*." I have a Colorado *mæsta*, identified by Mr. Fox, and *gilensis* differs in the longer lateral teeth of the scutellum; the abdomen with strong, close punctures, as large on the second segment as on the first; and the rufous tarsi. The last segment of the abdomen is considerably more produced than in ♂ *octodentata*.

Subfamily. MEGACHILINÆ.

STELIS.

7 mm. long, or less; black with bright yellow markings; abdomen banded with yellow and black; marginal cell and adjacent parts of wing fuliginous. (Santa Fé, Gila R.) . . . *costalis*, Cress.

ANTHIDIUM.

Head entirely black, except a white spot at the summit of each eye. (Northern N. M.) . *emarginatum*, Say, var. *atrifrons*, Cress., ♀.

Face with at least some light markings, ... 1

1. Clypeus all light, or with only the edge dark, . 2

Clypeus partly dark, ... 5

2. Markings largely ferruginous, legs ferruginous. (Mesilla Valley, Chaves, Albuquerque.) . . . *curvatum*, Smith, (*interruptum*, Say.)

Colors black and yellow or white, ... 3

3. Abdomen with the yellow bands notched behind. (Santa Fé.) . . . . . *pudicum*, Cress., ♂.

Abdomen with the yellow bands notched in front, or divided into spots, ... 4

Abdominal bands entire, not conspicuously notched; legs yellow, tinged with ferruginous. (Mesilla Valley.) . . . . . *larreæ*, Ckll.

4. Large, yellow marks rather pale, femora and most of tibiæ black. (Mesilla Valley.) . *maculifrons*, Smith, ♂.

Smaller, about 10 mm. long, yellow very bright, legs yellow and ferruginous. Flagellum, except first joint, ferruginous beneath. Yellow markings of head and thorax as in *maculifrons*. (Mesilla, June 17, at fls. of *Parosela scoparia*) . . . . *paroselæ*, Ckll., n. sp. ♀.

Length about 10 mm., face-markings white; legs black, tibiæ marked with white and with a ferruginous spot at apex, tarsi white, dusky at tips. (Northern N. M.) . . . *occidentale*, Cress., ♂.

5. Abdominal bands not notched or divided sublaterally, but more or less divided in the middle line. (Ruidoso Creek, Aug. 20, 1897; E. O. Wooton.) *perpictum*, Ckll., n. sp. ♀

Abdominal bands divided in the middle, and notched sublaterally behind. (Santa Fé.) *pudicum*, Cress., ♀.

Abdomen with a yellow spot on each side of first segment, a yellow band divided only in the middle on second, yellow bands broadly divided medially and sublaterally on third to fifth, no yellow at all on sixth segment. Size small; legs ferruginous, yellow and black. (Gila R.) . . . . *gilense*, Ckll., ♀.

Larger, abdominal bands entirely divided into distant spots; no yellow on face except two large blotches on clypeus. (Tuerto Mtn., 8025 ft.) . *maculosum*, Cress.

Abdominal bands notched sublaterally in front, or even there divided but then the spots much larger than the intervals between them, ... 6

6. Ventral scopa fulvous; scutellum with two light spots. (Northern N. M.) . . *occidentale*, Cress., ♀.

Ventral scopa white; scutellum with four spots. (Mesilla Valley, Organ Mts.) . . *maculifrons*, Smith, ♀.

Note.—*A. perpictum* is about 9 mm. long, and agrees in most respects with the Mexican *A. flavolineatum*, Smith. The femora are black; all the knees ferruginous; tibiæ ferruginous suffused with black behind; tarsi ferruginous, hind tarsi strongly stained with black. Sides of clypeus occupied by large triangular patches, of which the upper half is yellow and the lower orange; sides of face yellow up to summit of eyes. Wings quite dark. Ventral scopa white. Tegulæ ferruginous. Scutellum with an interrupted yellow band, but lateral angles spotless.

OSMIA.

Females.

Ventral scopa black, ... 1

Ventral scopa pale fulvo-ochraceous; head and thorax olive green, with white pubescence; tegulæ shining rufotestaceous. (Mesilla Valley.) . . . . . *phenax*, Ckll.

Ventral scopa black in middle and yellowish-white at sides; tegulæ black. (Mesilla Valley.) . . . . . *prunorum*, Ckll.

1. Length 9½ mm., pubescence of thorax above bright rust-red. (Mesilla Valley.) . . . . *cerasi*, Ckll.

Larger, dark blue, pubescence of thorax dull white and black mixed; clypeus broadly and deeply notched. (Organ Mts., Paraje.) . . . *lignaria*, Say.

MONUMETHA.

About 14 mm. long, black; occiput and pleura with sooty hair; thorax above with dull white hair; lateral margins of first two abdominal segments with white hair-patches. (Gila R.) . *borealis*, Cress.

ALCIDAMEA.

About 13 mm. long, black, with white and mouse-grey pubescence. In general appearance like *Andrena electrica.* (Mesilla Valley.) . . . *biscutellæ*, Ckll., ♂.

ASHMEADIELLA.

Abdomen red. (Mesilla Valley.) . . . . . *holtii*, Ckll.
Abdomen black, ... 1
  1. Legs partly red; length about 5½ mm. (Mesilla Valley.) . . . . . *bigeloviæ*, Ckll.
  Legs entirely black, ... 2
  2. Large species, over 8 mm. long, ... 3
  Smaller, under 7 mm.; tegulæ black or piceous, . 4
  3. Tegulæ dark ferruginous. (Organ Mts., May, at fls. of *Opuntia.*) . . . . . . *opuntiæ*, Ckll.
  Tegulæ black. (Albuquerque, Sept., at fls. of *Grindelia*) . . . . . *bucconis*, Say.
  4. Length 5 mm. (Mesilla Valley, at fls. of mesquite.) . . . *prosopidis*, Ckll., ♀.
  Length about 7 mm. (Santa Fé, at fls. of *Cactus.*) . . . . . *cactorum*, Ckll., ♀.
  Length about 6½ mm., head large. (Mesilla Valley.) . . . . . *meliloti*, Ckll., ♂.

HERIADES.

Front legs partly red; length about 5 mm. (Mesilla Valley.) *asteris*, Ckll.
Legs entirely black, ... 1
  1. First recurrent nervure uniting with first transverso-cubital. (Santa Fé.) . . . . *crucifera*, Ckll.
  First recurrent nervure not so uniting, . . 2
  2. Length 8 mm. or over. (Organ Mts., at fls. of *Opuntia.*) . . . . . *gracilior*, Ckll.
  Length less than 8 mm., punctures on third abdominal segment much larger than those on second. (Santa Fé, Mesilla Valley, etc.) . . . . *carinata*, Cress

LITHURGUS.

About 16 mm. long; resembles a *Megachile.* Abdomen with narrow white hair-bands, apex with fusco-fulvous hair. (Santa Fé, Mesilla Valley.) . . . . *apicalis*, Cress.

MEGACHILE.

Males.

Front tarsi ordinary, ... 1
Front tarsi peculiar, ... 2

1. Shape narrow; apex of abdomen notched but not produced. (Gila R.) *exilis*, Cress.
   Broader; apex of abdomen produced, deeply notched, and bent downwards. (Mesilla Valley.) *townsendiana*, Ckll.
   Broad, 13 mm. long; abdomen subquadrate, apex coarsely serrate and deeply notched, *texana*, Cress.
2. Abdomen without hair-bands; last joint of antennæ dilated and flattened. (Ruidoso Creek.) *wootoni*, Ckll.
   Abdomen with hair-bands, 3
3. First joint of anterior tarsi produced to a free apex, 4
   First joint of anterior tarsi not produced to a free apex, 5
4. The free apex like the end of a finger; hair-bands of abdomen fulvous. (Gila R.) *fidelis*, Cress.
   The free apex not like the end of a finger; hair-bands white. (Santa Fé.) *pugnata*, Say.
5. Thorax very pubescent, the pubescence more or less ochreous or fulvous, 6
   Thorax not very pubescent, the pubescence pale greyish to white, 8
6. Flagellum slender, not crenulated beneath. (Santa Fé.) *latimanus*, Say.
   Flagellum stout, crenulated beneath, 7
7. Pubescence of thorax yellowish-grey. (Tuerto Mtn., near Santa Fé) *comata*, Cress.
   Pubescence of thorax fulvous. (Gila R.) *fortis*, Cress.
8. Anterior legs slender; anterior tarsi with basal joint merely expanded into a flat lamina at the side. (Mesilla Valley.) *occidentalis*, Fox.
   Larger; anterior femora stout, subtriangular in section, 9
9. Anterior femur yellow where it touches tibia; pubescence of face yellowish. (Deming, Lone Mtn., Mesilla Valley.) *sidalceæ*, Ckll.
   Anterior femur rufous where it touches tibia; pubescence of face white. (Mesilla Valley.) *casadæ*, Ckll.

Females.

Large and robust, length 14 mm. or over, 1
Smaller, length under 13 mm., 2

1. Ventral scopa pale fulvous, *latimanus*, Say.
   Ventral scopa white; black on the last two segments. (Ruidoso Creek.) *texana*, Cress.
2. Abdomen short and broad; ventral scopa white, black on last segment. (Mesilla Valley.) *brevis*, Say.
   Abdomen long and narrow, 3
3. Ventral scopa white, black on last segment; tegulæ orange brown, *occidentalis*, Fox.
   Ventral scopa entirely dull white; tegulæ piceous, strongly punctured, *exilis*, Cress.

Note.—Several other species of *Megachile* have been collected, but not yet studied. It is not certain that what is called *brevis* here is in reality Say's species. A specimen of *M. brevis* from Mr. Robertson has the ventral scopa all white. Say's description does not indicate whether it should be black at the tip or not.

Subfamily. PODALIRIINÆ.

MELISSODES.

Males.

Clypeus black, ... 1
Clypeus yellow, ... 2
1. Larger, antennæ longer than head and thorax; mandibles with no yellow spot. (Mesilla Valley, San Marcial.) *tristis*, Ckll.
Smaller, antennæ reaching only to metathorax; mandibles with a yellow spot. (Santa Fé.) . *sphæralceæ*, Ckll.
2. Antennæ yellow; thorax with bright fulvous pubescence. (Rincon, Mesilla Valley.) . . *luteicornis*, Ckll.
Antennæ not yellow, ... 3
3. Flagellum entirely black. (Ruidoso Creek.) *ruidosensis*, Ckll.
Flagellum more or less ferruginous beneath, . 4
4. Pubescence of middle of thoracic dorsum black. General size and form of *aurigenia*. Pubescence, where not black, dull white to pale ochraceous. Mandibles with no yellow spot. Nervures piceous. (Santa Fé, July and Aug., at fls. of *Grindelia*, *Lepachys* and *Rudbeckia;* also Tuerto Mtn., 8875 ft.) . . *grindeliæ*, Ckll., n. sp.
Pubescence of thoracic dorsum ochraceous or greyish, (some little black in *montana*.) . . . 5
5. Very large and robust, antennæ only moderately long; mandibles partly yellow, ... 6
Smaller, with long antennæ, . . . 7
6. Abdomen dark, with hair-bands. (Santa Fé.) *obliqua*, Say.
Abdomen entirely covered with fulvous hair. (Mesilla Valley.) . . . . . *townsendi*, Ckll.
7. Last dorsal segment of abdomen with fuscous hair; mandibles with a yellow patch, . . . 8
Last dorsal segment of abdomen with light hair, 9
8. Scutellum with black hair; base of fourth abdominal segment without black hair. (Gila R.) *montana*, Cress.
Scutellum without black hair; base of fourth abdominal segment with much black hair. (Mesilla Valley.) . . . . *communis*, Cress.
9. Larger; about 12 mm. long, ... 10
Smaller; about 10 mm. long, ... 11
10. Mandibles with a yellow spot. (Santa Fé.) *menuacha*, Cress.
Mandibles without a yellow spot. (Albuquerque, Mesilla Valley.) . . *menuacha* var. *submenuacha*, Ckll.

11. Pubescence pale grey, with a faint ochreous tinge. (Mesilla Valley, Socorro, Albuquerque.) . *agilis*, Cress.
Pubescence more or less strongly ochraceous. (Santa Fé.) . . *agilis* var. ***aurigenia***, Cress.

Note.—The male of *grindeliæ* is readily separated from that of ***montana*** as follows:

Third and fourth abdominal segments covered, even at base, with very pale ochraceous hair; last segment with fuscous or black hair; mandibles with a yellow spot, ***montana***, Cr.
Third and fourth segments with the black surface exposed except on apical margins; last segment with ochraceous hair; mandibles with no yellow spot, . *grindeliæ*, Ckll.

Females.

Hair on inner side of basal joint of hind tarsus black or fuscous, 1
Hair on inner side of basal joint of hind tarsus ferruginous, . 4
1. Pubescence of thorax above bright fulvous, *luteicornis*, Ckll.
Pubescence of thorax above pale, with some black, . 2
2. Some black hair behind ocelli. Head not so broad as in *pallidicincta*, much like *confusa*, for which it has been taken, but hair of legs, except on inner side of tarsi, and somewhat on apices of tibiæ, entirely dull white. (Santa Fé, with the ♂.) . *grindeliæ*, Ckll., n. sp.
Hair behind ocelli all pale, ... 3
3. Larger, head extremely broad, abdomen with conspicuous white hair-bands. (Gila R., Santa Fé, etc.) *pallidicincta*, Ckll.
Smaller, head not so broad. (Mesilla Valley.) ***intermedia***, Cress.
4. Very large and robust, about 16 mm. long; pubescence of pleura black, ... *obliqua*, Say.
Smaller, pubescence of pleura ochraceous or grey, 5
5. Scutellum and middle of mesothorax with conspicuous black hair. (Gila R., etc.) . . *gilensis*, Ckll.
Dorsum of thorax without black hair, or with only a few inconspicuous black hairs, . . . 6
6. Larger, pubescence of thorax pale ochraceous, *menuacha*, Cress.
Smaller, pubescence of thorax bright fulvous or at least strongly ochraceous, . *agilis* var. ***aurigenia***, Cress.

Note.—Several other species of *Melissodes* have been collected in the female sex, but are not at present named, the material being rather inadequate for satisfactory study. *M. nevadensis*, Cress., has been taken in the Mesilla Valley, but I have no specimens at hand at the present time.

XENOGLOSSA.

Legs, except the tarsi, black; size smaller. (Mesilla Valley.) *pruinosa*, Say.
Legs wholly rufous or fulvous; size larger, . . . 1
1. Abdomen red, very large and stout species. (Mesilla Valley, Gila R.) . . . . *patricia*, Ckll.
Abdomen black. (Mesilla Valley.) . *strenua*, Cress.

Note.—All these species may be found in the flowers of *Cucurbita*.

Diadasia.

Abdomen with clean-cut hair-bands; bases of second to fourth segments free from pale hairs. (Rincon.) . . . . ***rinconis*, Ckll.**

Abdomen hairy all over, ... 1

1. Rather large; hind tarsi with a large finger-like process. (Santa Fé, June, at fls. of *Opuntia*.) . ***australis*, Cress.**

Hind tarsi without such a process, ... 2

2. Very large; ♂ very robust, with more or less distinct abdominal hair-bands. (Mesilla Valley, and by the White Sands.) . . . . . ***megamorpha*, Ckll.**

Little over 10 mm. long; covered all over with yellowish pubescence, very dense and uniform on abdomen. (Rincon, Organ Mts., Santa Fé, Mesilla Valley, Deming, etc.) . . . . . ***enavata*, Cress.**

Very small, about 8 mm., with pale grey or greyish-white pubscence. (Mesilla Valley, Santa Fè.) ***diminuta*, Cress.**

About 8 mm. long, differs from ***diminuta*** by having the pubescence on the abdomen not uniformly dense, but thinner, leaving the apical hair-bands distinct, ***apacha*, Cress. ♀.**

Synhalonia.

About 15 mm. long, with dull white pubescence, tinged with yellowish on thorax; brush of hind tarsi very bright ferruginous; abdomen black, with first segment covered with greyish-white hair, and hair-bands of the same color on segments 2 and 3, the hair of these bands being appressed and very short. (Mesilla Valley.) ***lycii*, Ckll.**

Habropoda.

Rather large, robust, with a broad abdomen. Pubescence black and greyish-white mixed. Abdomen with very distinct hair-bands. Clypeus in ♂ with a reversed T in white; narrow white lateral face-marks, reduced to a line above. Face of ♀ black. (Top of Organ Mts.) . . . . . . ***salviarum*, Ckll.**

Podalirius. (Anthophora.)

Hind margins of abdominal segments with chalk-white bands, not due to hair, ... 1

Hind margins of segments without such bands, ... 4

1. Thoracic pubescence mixed black and mouse-grey; clypeus of ♂ white, with the lateral margins broadly black. (Santa Fé.) . . . . . ***cleomis*, Ckll.**

Thoracic pubescence greyish or ochraceous, with no black hairs, ... 2

2. Clypeus and sides of face yellow. (Deming, Mesilla Valley.) . . . . . . ***californicus*, Cress.**

Clypeus and sides of face white, ... 3

3. Apical joint of middle tarsi ciliated laterally with black pubescence in ♂ (Vega S. José.) . ***walshii*, Cress.**

Middle tarsi without any black pubescence. (Lone Mtn. near Silver City.) . . . *cardui*, Ckll., ♂.

4. Apical joint of middle tarsus of ♂ with a broad brush of black hair on each side, the whole shaped like the end of a peacock's feather. (Mesilla Valley.) *lesquerellæ*, Ckll.

Not so, ... 5

5. Small species, length less than 10 mm., . . . 6

Large, over 10 mm., ... 7

6. Eyes green; clypeus broadly magined with yellow. (Mesilla Valley, Santa Fé, Embudo.) . *maculifrons*, Cress.

Eyes dark purplish; clypeus white in ♂, black with a very narrow white apical stripe in ♀. (Mesilla Valley; the ♀ discovered April 29 by C. M. Barber.) . *phenax*, Ckll.

7. 15 to 17 mm. long; entire body covered with short, dense, mouse grey to fulvous pubescence; basal joint of hind tarsi of ♂ toothed within. (Santa Fé.) . *occidentalis*, Cress.

Abdomen not fasciate, the first and second segments, and sometimes more or less of the third, clothed with short ochraceous pubescence, the rest black or brownish. (Santa Fè.) . . . . *bomboides*, Kirby.

Abdomen not fasciate, the first and part of the second segments with ochraceous pubescence, the rest of the abdomen black. Large, robust species. Basal joint of hind tarsi of ♂ simple. (Organ Mts., Vega S. José.) . . . . . *ursinus*, Cress.

Abdomen more or less fasciate. 8

8. Abdomen with broad, entire, dense, yellowish-white hair-bands; thorax with mouse-grey hair intermixed with black. (Albuquerque, western base of Organ Mts., Canada Alamosa.) . *urbanus*, Cress., var. *alamosanus*, Ckll.

Abdomen with narrow or weak hair-bands, . . 9

9. Large, about 17 mm. long; abdomen with very narrow hair-bands; clypeus of ♂ pale yellow; eyes green. (Mesilla Valley.). . . . . . *affabilis*, Cress

About 13 or 14 mm. long; tip of fifth abdominal segment in ♀ with dense black pubescence. (Vega S. José.) . . . . . . *montanus*, Cress.

12 mm. long; fifth abdominal segment in ♀ covered with black hair. Differs from Cresson's description of *montanus* ♀ in having mandibles not fulvous before apex, pubescence of thorax with black intermixed, apical margins of wings not at all dusky, outer side of tibiæ clothed with silvery-white hair; ♂ with clypeus and sides of face yellow. (Mesilla Valley.) . *vallorum*, Ckll.

Note.—The ♀ of *lesquerellæ* is hard to distinguish from that of *vallorum*, but is rather larger, has rather shorter antennæ, and flies earlier in the year,—in April.

ANTHOPOHRULA.*

About 6½ mm. long, short and compact, like a small *Diadasia* or *Podalirius*, pubescence pale mouse-color, covering most of abdomen with a dense felt, Flagellum fulvous. (Mesilla Valley.) . . . . . *compactula*, Ckll.

CENTRIS.

Males.

Front broad, ... 1
Front narrow, ... 3
1. Length over 14 mm., scape without yellow, . . 2
   Length under 14 mm., scape yellow in front, . *rhodopus*, Ckll.
2. Very large, 21 mm. long, pubescence of thorax mouse-color, abdomen with two more or less distinct reddish bands, ... *morsei*, Ckll.
   Length 16 mm., pubescence of thorax ochraceous. . . . . . *cæsalpiniæ*, Ckll.
3. Abdomen with narrow hair-bands; clypeus yellowish-white, ... *hoffmanseggiæ*, Ckll.
   Abdomen without hair-bands; clypeus lemon yellow, ... *lanosa*, Cress.

Females.

Clypeus crimson, ... 1
Clypeus yellow or orange, the upper border more or less black, . . 2
1. Length over 14 mm.; legs black, . . *cæsalpiniæ*, Ckll.
   Length under 14 mm.; femora and tibiæ rufous, . *rhodopus*, Ckll.
2. Second abdominal segment pubescent, . *lanosa*, Cress.
   Second abdominal segment bare, . *hoffmanseggiæ*, Ckll.

Note.—*C. morsei* was taken at the end of June; all the others can be found at flowers of *Cæsalpinia* (*Hoffmanseggia*) *falcaria* in May. All occur in the Mesilla Valley.

OXÆA.

Wings on apical half blue-black; legs reddish; abdomen black, on the sides, beneath, and sixth or seventh dorsal segments with fulvous pubescence. Length 22 mm. (Mesilla Valley.) . *gloriosa*, Fox.

Note.—This was described as a *Megacilissa*, but it differs in the venation from that genus. I had referred it to *Oxæa*, and Mr. Friese, to whom I sent a specimen, places it in that genus.

MEGACILISSA.

Wings not or but slightly fuscous apically; abdomen dorsally black, with the apical margins of segments 2 to 4 with white pubescence. (El Rito.) . . . . . , . *yarrowi*, Cress.

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*Since this was sent to press I have ascertained that *Anthophorula* is in reality an *Exomalopsis* with two marginal cells.

EXOMALOPSIS.

Abdomen of ♀ red, of ♂ black. Length 7 to 8 mm. (Mesilla, at fls. of *Sida hederacea.*) . . . . *sidæ*, Ckll.

Rather larger, entirely black, pubescence all pale. (Mesilla Valley, Albuquerque.) . . . . . . *solani*, Ckll.

Subfamily. XYLOCOPINÆ.

XYLOCOPA.

Over 20 mm. long, very large and robust; dark blue, shining; pubescence black; wings fuliginous. (Mesilla Valley, Lone Mtn. near Silver City.) . . . . . . *arizonensis*, Cress.

CERATINA.

Length 4½ mm., shining, very dark bluish-green, brassy-green on mesothorax. A cream-colored clypeal mark. Abdomen ending in a short point. (Mesilla Valley,) . . *nanula*, Ckll., ♂.

Subfamily. BOMBINÆ.

BOMBUS.

Abdomen with an orange-red band, ... 1

Abdomen with a black band, black also at base; thorax with a black band. (Santa Fé Canon) . . . . . *howardi*, Cress.

Abdomen with black pubescence at base and apex, fulvous in the middle. (Mesilla Valley.) . . . . *americanorum*, Fabr., ♀.

Abdomen with fulvous pubescence, dark brown at tip; wings entirely fuscous, ... *nevadensis*, Cress.

Abdomen with bright yellow pubescence, black at tip (in ♀ nearly the the apical half black); thorax with the same bright yellow pubescence, and no black band; wings fuliginous. (Mesilla Valley, Organ Mts., Lamy, Watrous, Albuquerque, Santa Fé, &c) . *morrisoni*, Cress.

Abdomen with the pubescence entirely fulvous; thorax with a black band, ... 2

1. Abdomen with the pubescence orange on second and third segments, yellowish on first and fourth, black at apex, ... *ternarius*, Say.

   Abdomen with the pubescence orange on third and fourth segments, black on fifth and sixth. (Santa Fè Canon, Ruidoso Creek) . . . . . *juxtus*, Cress.

2· Pubescence of thorax, before the black band, yellowish white. (Santa Fé Canon.) . . *appositus*, Cress.

   Pubescence of thorax, before the black band, fulvous like that behind it, ... *americanorum*, Fabr., ♂.

Subfamily. APINÆ.

APIS.

Not native in New Mexico. Includes *A. mellifera*, Linné, the honey bee. The variety commonly kept in New Mexico is the Italian, distinguished by the abdomen being largely light fulvous.

APPENDIX TO ARTICLE III. VOLUME XI.

NOTES ON BEES TAKEN AT ALBUQUERQUE, NEW MEXICO, IN SEPTEMBER, 1897.

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Entomologist of the New Mexico Agricultural Experiment Station.

The following list is the result of some collecting done by the writer at Albuquerque during parts of three days in September. Only one of the species has been recorded before from that locality, and a few are new to New Mexico. In Bull. 24 of the N. M. Experiment Station, pp. 22-23, 13 bees are recorded from Albuquerque; the present list brings the number to 28.

(1). *Prosapis asinina*, Ckll. and Casad, 1895, var. *bigeloviæ*, n. var.—Female; differs by having the punctures of the first abdominal segment considerably smaller and weaker, hind margins of abdominal segments broadly rufescent, sides of abdomen with no noticeable white hair, scutellum with a distinct median longitudinal groove (wholly wanting in the typical form). Possibly a distinct species. One at flowers of *Bigelovia wrightii*, Sept. 16. Specimens taken at Mesilla, N. M., Sept. 4, at flowers of *Bigelovia wrightii*, are not *bigeloviæ* but ordinary *asinina*.

(2). *Colletes armata*, Patton, 1879—Sept. 15, two females at flowers of *Bigelovia wrightii*.

(3). *Andrena helianthi*, Rob., 1891—Sept. 16, two females at flowers of *Helianthus annuus*. New to New Mexico. The legs are black, not "dull ferruginous," as Robertson describes; they are also black in a specimen received from Mr. Robertson.

(4). *Nomia nevadensis*, Cresson, 1874—Sept. 16, one male and one female at flowers of *Bigelovia wrightii*. I have also a male which I took in Albuquerque, June 30, at flowers of *Fallugia pardaoxa*.

(5). *Nomia persimilis*, n. sp.—Female, length about 14 mm.; black with short greyish pubescence. Facial quadrangle about as broad as long; head little hairy, sides of face with sparse short hairs; no lateral facial depressions; clypeus bare, subcancellate from close punctures all over, no smooth line; rest of face sculptured like clypeus; vertex strongly and very closely punctured; antennæ short, scape strongly punctured, flagellum wholly dark; mandibles dark reddish in middle; process of labrum subtruncate, very broad and little produced; anterior edge of clypeus with a conspicuous fringe of orange hairs; thorax with very short pale greyish-ochreous pubescence; mesothorax with very large punctures, about as close as it is possible for them to be; enclosure of metathorax bow-shaped, but broader at the sides than in the middle, irregularly subreticulated by raised lines, its boundary a strong ridge; tegulæ rufous; wings yellowish-hyaline, apical margin broadly smoky, nervures dark brown; stigma ferruginous, rather small; legs black; abdomen without hair-bands, strongly and extremely closely punctured, hind margins of segments not at all greenish. The male has the hind tibiæ broad and flattened, the inner apical corner produced into a blunt spine.

I first met with this species on the morning of Sept. 11, 1895, in a sandy place in the Mesilla Valley, near to the Agricultural College. The females were very abundant, flying over the sand like bembecides; making deep, large burrows straight down in the sand, and throwing up quite conspicuous piles of earth. Some were heavily loaded with orange pollen. All were females, and without the male I could not tell whether the species belonged to *Nomia* or *Eunomia*. Next, Prof. L. Bruner sent me a single female collected at Lincoln, Nebraska, in August. In Albuquerque I met with the species between the old and new towns, Sept. 16, and took three males and four females. The males enable me to refer the insect to *Nomia*, of which it is a very distinct new species. It is curious that all the males were on an *Aster* with purple rays, while the females were at the flowers of *Helianthus annuus*, gathering pollen. The females have the strongest possible superficial resemblance to *Andrena helianthi*, which was visiting the same flowers, so that when collecting I had no idea that there were two species before me.

(6). ***Pseudopanurgus æthiops*** (Cresson, 1872)—Sept. 16, one female at flowers of *Helianthus annuus*.

(7). ***Perdita zebrata***, Cresson, 1878—Sept. 15, four at flowers of *Cleome serrulata*.

(8). ***Perdita albipennis***, Cresson, 1868, var. *hyalina* (Cresson, 1878.)—Sept. 16, one male and two females at flowers of *Helianthus annuus*. The variety is new to New Mexico.

(9). ***Anthidium curvatum***, Smith, 1854 (*interruptum*, Say, 1824, not Fabr.)—Sept. 16, one at flowers of *Helianthus annuus*.

(10). ***Epeolus occidentalis***, Cresson, 1878—Sept. 16, two worn examples, one at flowers of *Bigelovia wrightii*.

(11). ***Epiolus remigatus***, Fabricius, 1804—Sept. 15, one.

(12). ***Podalirius urbanus*** (Cress., 1878), var. *alamosanus* (Ckll., 1896)—Sept. 15, four females at flowers of *Cleome serrulata*; Sept. 17, one female. This was described as a species, but it is only a feebly-distinguished race of ***urbanus***.

(13). ***Melissodes agilis***, Cresson, 1878—Sept. 16, at flowers of *Helianthus annuus*.

(14). ***Melissodes menuacha***, Cress., 1868, var. *submenuacha*, Ckll., 1897—one male, Sept. 17.

(15). ***Ashmeadiella bucconis*** (Say, 1837, as *Osmia bucconis*)—Sept. 17, one female, at flowers of *Grindelia*, new to New Mexico.

(16). ***Bombus morrisoni***, Cresson, 1878—Sept. 15, two males, one female, the latter at flowers of *Cleome serrulata*.

MESILLA PARK, N. M., Dec. 15, 1897.

BULLETIN OF THE UNIVERSITY OF NEW MEXICO.
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*PAPERS ON THE GEOLOGY OF NEW MEXICO.

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The following pages are derived from the results of studies carried on at intervals during four years. Several articles in the American Geologist have discussed certain features of the geology of the territory and may be considered to form a part of the present series. The enormous area over which these investigations must extend before they can approach completeness and the interrupted course of the field work unite to prevent any symmetrical prosecution or publication of the work. It has seemed best therefore to print the results in sections covering definite areas more or less cursorily and to leave the task of correlating the data to a later period. These articles then do not presume a knowledge of the geology of the territory at large, as they ought to do in order to be complete, but are materials toward a more synthetic study in the future. It is hoped that this method of publication will serve a good purpose in stimulating further work and in aiding in the practical development of the region.

I.

THE GEOLOGY OF THE SOCORRO MOUNTAIN.

With Plates IX, X and XI.

Probably nowhere in the territory can more suggestive geological data be found in so limited a space as in the small group of mountains lying immediately west of the town of Socorro and bearing that name. The mountain front at the north is prominent and precipitous, while the eastern face is elsewhere broken by intersecting canons and depressions. We here have in epitome the geological history of the entire region. The stratified rocks are represented by a few hundred feet of the lower portion of the Carboniferous limestones with the subjacent quartzite. This series, which must at one time have been continuous with the same formation in the Magdalena region to the west, the Limitar region to the north and the Sandia, Manzana region to the north-east, is here exposed only as a mere fragment in the side of the mountain-escarpment, where its upturned edge is exposed as it dips into the mountain, that is, to the west. Small as is the extent, the exposure is a good one and has afforded a large number of fossils. Near the bottom is the horizon of Productus cora and Spirifer opimus. The section at this place is as follows:

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*Reprinted from the Bulletin of the Scientific Laboratories of Denison University, Vol. XI.

The limestone is capped by flows of brecciated material that speak of explosive volcanic activity. These flows are of trachytic nature but are not the first of the volcanic outbursts to which the mountain owes its origin. The trachyte rears its head to the height of 8000 feet in the form of a high promentory from which a sharp ridge extends westward for over a mile, forming the northern wall of an ancient crater of great extent. The flows from the crater have extended to the northward in descending cascades and gentle streams to the point where the range is abruptly cleft by the Nogal canon. To the north still was another trachyte volcano which has left a mighty spur known far and wide as strawberry Peak. This volcano also had its period of tremendous explosive outbreak as is shown by the great mass of breccia and talus-conglomerate collected in the region to the northeast and laid open by a second canon to the north of Nogal canon.

Even in the amphitheatre of what we take to be the seat of the old trachyte volcano are here and there similar deposits, especially towards the north-east and south-east sides. These breccias and talus conglomerates yield on erosion most fantastic and architectural forms and the castellated peaks and odd mural shapes are characteristic of the deposits. Plate X, from the south side of the great crater-like area refered to and on the south side of the Blue Canon road, gives an idea of the conditions. As already said, the trachyte period was not the earliest stage of eruptive activity. The proof of this assertion is found in certain obscure but important masses of andestite found usually under the later flows. The limestone did not extend south of the principal Socorro peak but is abruptly cut off by a dark mass of andesite. The andesite projects beneath the trachyte and rhyolite of the mountain and has been entered by a number of mining tunnels, notably that of the Merritt mine which has produced at various times considerable silver and gold. Small rich bits of gold-bearing rock are encountered from time to time, though the miners have hardly yet learned that it is derived from the andesite contact alone. To the south the deep cleft known as Blue Canon has cut into the trachyte crater and in so doing has laid bare the andesite to a considerable extent and here we encounter exposures of the unaltered rock so like in its section to the diabase porphyrite of the lake Superior region as to be indistinguishable. Where ever the acid rocks have come in direct contact with the andesite in a state of fluidity and with thickness enough to permit of metamorphism there seems to have been some segregation of ore. In other cases, where the two have been left in juxtaposition and where water has access to the contact there has been extensive kaolinization of the andesite and a certain amount of similar decomposition of the acid rock also. These beds of kaolin which are used in the clay works of Socorro are very instructive as illustrating the effects of interaction of the two rocks even without heat as a factor. The mines of the Socorro mountain are also cases in point in proof of the thesis elsewhere maintained that the segregation of gold and silver ores is closely associated with a particular kind of metamorphism between basic and acid rocks.

The western boundary of the trachyte area is formed by a series of mountains terminating in a single abrupt conical hill of trachyte which we have designated as "pyramid mountain" and which is skirted on the south by the new Blue Canon road. To the west the whole northern part of the range is composed of granite or gneiss. The axis of the main ridge running east and west is nearly as high as Socorro mountain proper and the contact with the trachyte is sharp with some traces of metamorphism but no definite evidence as to the sequence. It may be presumed that the granite outpour was cotemporaneous with that of the trachyte. It may be suggested that the granite is due to metamorphism of preexisting sedimentary rocks fused by the action of the immense volcano. In this case, as in all others of this portion of the territory, the trachyte flows were followed by others of a still more acid nature. It would seem that these latter flows were not so much from the crater as along a great irregular fissure extending south from the vent. A series of waves of such material forming quartz trachyte and rhyolite form the abrupt range facing the river and extending four or five miles southward from Socorro mountain proper. The foot hills are all of talus conglomerate with boulders of various sizes up to 18 inches or two feet in diameter. Appearances seem to show that at this time the surrounding region was under water. Toward the south end of this series a considerable flow of white obsidian is found and obsidian sheets cover poorly cemented detrital material of the same age. The most prominent of the hills of the trachyte series lies west of the smelter settlement known as Park City and from the west affords an abrupt front with basaltiform columns. We have called it Pallisade mountain. Plate XI, Fig. 1. Pallisade mountain from the northwest showing recent strata at 3. The foreground (4) is a granite hill over which the Blue Canon road passes. To the southward a spur passes for a mile or more at a low elevation toward the Magdalena rail road. This projection offers an opportunity for the study of alteration phenomena, of which more beyond. In the south-eastern part of the area no evidence of the oldest or andesite period is revealed but in the south-western angle at Clemou an aphanitic phase of the basic eruptive is left uncovered by the basalt that covers the south-west one fourth of the quadrangle and has been eroded by the arroyo as well as cut by the railroad. Here too is evidence of explosive activity in the form of masses of talus conglomerate (See Plate XI, Fig. 2). 1. Talus conglomerate. 2. basis eruptive. 3. Magdalena Mountains in distance.

The south-west quarter of the area under consideration, as already hinted, is covered with a flow of dark basalt of an average thickness of not more than twenty-five feet which, near the margins, is reduced to five. The area over which this flow is undisturbed is only a fraction of the whole but in a large part of the area there has been extensive undermining of the soft material upon which the lava reposes. Thus the mile or more intervening between the lava sheet and Pallisade mountain has been transformed into a desperate kind of *mal pais* in which the large fragments of lava are upturned in all directions, making it practically impassible. The source of the flow is apparently at a point at present separated from the main sheet, to the west of the "Cactus Plain" through which the rail road passes to Magdalena. The region of "Indian Hill" is also a portion of this flow. In a deep canon in the last mentioned series of hills deeper parts of the flow, apparently in the channel of outlet, are exposed and here the nature of the rock is different from the superficial portions as elsewhere described. From this region the lava seems to have spread to the north and east but it has been removed wholly in the valley of the stream that in wet times skirts the western border of the Socorro mountain region as well as over broad valley intersecting that range from the middle of its western margin and forming the southern boundary of the granite area. The history of the region from the end of the rhyolite period to the overflow of lava, so far as it is recorded, is preserved in a loose fragmental series the materials of which are apparently derived from the adjacent rocks. This is well exposed in the south-eastern part of the region where are a variety of lava-topped cliffs beneath which are sandstones and crags probably of quite recent origin. The flow extended for some distance north along the eastern face of the range and has left outliers in the form of lava-topped buttes of which the most conspicuous is near the springs which supply the city of Socorro with water. The underlying formation is here very largely derived from fragments evidently worn out of the earlier talus conglomerates. In the depressed area in the center of the region here under consideration, at the western foot of the Pallisade mountain, are remnants of the same horizontal strata Plate XI, Fig. 3, and their continuation below the large lava sheet to the west and south-west is easy to follow. These soft strata are easily undermined and as they are removed by percolating water the lava above breaks into irregular fragments under its own weight and ultimately these fragments are indiscriminately dropped into the space beneath.

To the north-east, nearly directly east of the peak known as Strawberry there is an extensive series of sandstone and shales some of which are full of gypsum fragments; these are often tilted, dipping toward the range, i. e. to the west. No fossils have been found and it is at present impossible to tell whether they are of Cretaceous age as the gypsum might suggest, or whether they are of the same age as the other loosely aggregated material of the region farther south. Near the base of the range there are a number of ancient basaltic dykes which bear intrinsic evidence of a greater age than those forming the surface flows. They are interbedded and we cannot say from the exposures seen whether they have been intercallated in the series before the disturbance or whether they too were at one time surface flows, and since that time have been imprisoned under later sediments.

Plate XI, Fig. 3. Panoramic view of the Socorro Mountains from the east, from a series of photographs, as seen from the city of Socorro. The numbers are placed with reference to sources of the rocks examined and will be referred to in the section on petrography. 1. Strawberry Peak; 2. Socorro Peak, between this and 1, Nogal Canon; 3. Promontory Peak; 4. Sharp Peak, north of which a dyke cuts off the limestone seen at 22; 5. similar small peak near which gold discovery has been made; 6. western granitic part of main range; 7. The upper and western of two flows of quartz trachyte flowing over andesite at 27; 8. western wall of the old crater about one mile west of 7; 9. hill forming southern wall of Blue Canon, the lower part of andesite, upper of trachyte and rhyolite; 10 to 13. various trachyte, rhyolite and breccia flows; 14. Pallisade Mountain; 15 to 19. hills of stratified gravel and sand covered with a thin flow of recent basalt; 20. flow of trachytic rock over the limestone; 21. quartzite at base of limestone; 22. Carboniferous limestone, about 400 feet thick; 24 to 26. andesite beneath the trachyte, Merritt and other mines; 26. beds of kaolin from decomposition of andesite and trachyte; 29. Blue Canon; 30. Rio Grande smelter; 31. spring; 32. spring and mill; 33. ranch; 34. clay.

2.

THE LIMITAR VOLCANO.

Limitar mountain is a member of the range bordering the Rio Grande on the west that lies north of the Socorro mountains. The interval between them is filled with lower ridges of the same materials as are seen in the main mountains, chiefly trachyte flows probably from fissures in the of axis upheaval. The stratified rocks are less disturbed. This mountain is about five mills from the river and directly west of the town by the same name so that it is easily visible from the Santa Fé rail road. It may be distinguished by the oblique band formed by a section of tilted limestone laid bare during a late explosion of the volcano. Between the river and the base is a series of sandstones and crags which may be of Pleistocene age or recent, while nearer the base are what may prove to be remnants of Cretaceous sands and shales with a sharp dip to the west and interbedded with ancient basalts. It would appear, however, that the later fragmental series is only mediately related to the eruptives which furnished their materials, for at the foot of the cores of eruption we generally find a different class of fragmentals. In the early history of our volcano, as well as at intervals subsequently, there were periods of explosive activity or else the products of eruption were cast, while still hot into the sea, there to be shaken up violently and detonated by the sudden cooling. There is evidence that both of these methods of comminuting the flows were in vogue at different times. Thus in some cases the resulting product is a coarse breccia with angular fragments and a very small amount of sand in the interstices, while in other cases, the binding material is of the substance of the flow which has caught up the exploded fragments in its course. Some are veritable talus-conglomerates within or near the crater itself, while others are but the selvages of anarachactic or narrow intrusive flows. It is also quite the rule in this as in other similar regions that the massive flows should catch up fragments of the adjacent or perforated country rock and incorporate them more or less completely in the pasty or fluid magma. It then, of course, follows that these fragments are themselves more or less altered while, if the heat was sufficient, the magma is likewise modified by the introduction into it, at various stages of cooling, foreign ingredients. In fact, nature has here performed for us some of the most difficult experiments feebly attempted in modern laboratories of synthetic geology and the study of the alteration phenomena both chemical and physical occurring in the rock fragments and in the "symmorphic" result of the integration of the various disparite elements by secondary fusion promises more for this branch of geology than any method available and yet, curiously enough seems hardly at all worked.[1]

We may picture to ourselves a time when the Cretaceous strata lay in practically undisturbed possession of the region. The time was long past when coal swamps occupied the great basins to the west and south-east and gradual elevations alternating for many years with slight depressions had afforded the conditions necessary to the formation of beds of gypsum and salt.[2] We may suppose that a long period of elevation had passed over the region without leaving any record except in extensive denudation and an occasional local deposit. There were doubtless secular contractions of the crust but at last a time came when the intrinsic strains overcame the rigidity of the crust and great orographic lines of weakness developed in approximately prrallel lines extending north and south over the whole area of the southern Rockies. The present course of the Rio Grande in central New Mexico occupies what may once have been the axis of such a fold, while the intersection of the western declevity with the present general level is marked by a fracture zone in which lie the chief centres of overflow. Elsewhere the greater igneous activity is on the eastern side though just what the determining circumstances were we are as yet unable to say. It is a well-known aphorism that the crests of greatest elevation, by reason of greater fracture and superior accessibility, become sooner or later the depressions and, *ceteris paribus*, the courses of the streams. Our area is no exception and the moutain ranges of the west bank of the river are considered to be secondary in the sense that they are, in part, the remnants left by erosion from the original uplift. To the preservation of these ridges the frequent and often extensive outpour of eruptive rocks has greatly contributed. At first it might seem that the vent for such overflows should have developed in the axis of the fold but the analogies as well as a variety of theoretical considerations reinforce the other view and sustain the evidence from the field. Thus the shear strains and the thickening and heat increment would be greatest near the sides at the base and the isogeotherms would accordingly be elevated at this place.[1] There is much reason to suppose that the materials of the eruptives are essentially of local origin, in fact that they are derived from the fusion of materials lying at no great depth beneath the site in which they now occur. The agencies of metamorphism being then greatest at the sides near the base and the techtonic strains there having a maximum it follows that the lower portion of the strata are there fused, the support for the rest is removed as a result, there is a faulting of the whole, causing the tilting of the series toward the axis of weakening on the "down" (here western) side and an outpour of fused material at the same time. If the thrust and outflow were violent there would be a second fault of the same sort to the west. This has apparently been the history of our region. The limestone occupying the upper part of the series is relatively infusible while the subjacent acid rocks consisting of sandstone and conglomerate was readily altered—in some cases to the point of complete fusion. The result has been local thickening of the acid rocks and their conversion into quartzites, hornblendic schists, gneisses and finally granite. This last stage in the metamorphism has been attained by the old sedimentaries in the Limitar range proper while to the north and south the place immediately below the lime is occupied by hornblendic schists with gneissic bands and veins of diorite. Passing south to the next centre of eruption (in the Socorros) the rock is simply a quartzite. At various times the theory has been advanced that granite is properly speaking always protogene and consequently that a metamorphic origin is impossible. But aside from the strong testimony from analogy in the present case, there occurs about half way from the base of the Limitar to the lower surface of the lime a band of limestone included in the granite. This band is about eighteen inches wide and contains, in spite of high metamorphism, some fossil remains, proving conclusively the sedimentary nature of the beds from which the granite has been derived. Below, the granite passes into gneiss and this into hornblendic schist both the latter being broken by diorite. The writer has attempted to show on the basis of the conditions on the north shore of lake Superior, that diorite is essentially paragenetic and not an independent intrusive. The evidence of the region in question is strongly in favor of this conclusion for the diorites all assimilate closely to the gneisses in which they solely occur.

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[1] Cf. Endlich, On the erupted rocks of Colorado. Hayden Survey Report for 1876.

[2] Salt springs occur only a few miles north-west of the Limitars and cause the waters of the Rio Salado to be decidedly salt to the taste.

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[1] Hot springs and secular vibrations still attest the elevation of the isogeotherms in this belt.

Seen from the south, our volcano appears as a broad-based cone from which skeleton ridges extend to the north-west and south. The entire eastern base is composed of the acid series just described, most characteristic being the red coarse granite with large quartz grains and sparsely and crudely mingled hornblende. Even at a great distance from the south one can detect the broad light stripe of obliquely tilted limestone where it is exposed by some vast eruptive outburst which not only tore open the very vitals of the mountain but plowed an enormous furrow across the lime and thus made good its escape to the south and east. Little is left to show of this flow but the eroded edge of the lime to the north and the tilted and scattered fragments in the hills to the south of the canon formed by it. In the amphitheatre-shaped cavity on the southern slope of the cone there is exposed a portion of a granite lying quite near the heart of original eruption, while above it are the brecciated fragments of the explosive phase of the eruption. The limestone dips into the crater cone at an angle of over 30 degrees and a part of its upper surface was left bare by the out-burst. Farther north, however, we find a spot where the original flow spread out over the lime. Here, in fact, was the theatre of a curious activity. It appears from examination of the fragments contained in this brecciated flow that the lava was essentially an andesite but where it came in contact with the lime a double interchange was affected. In spite of its great infusibility, the upper part of the lime was crystallized, forming a bed of calcite with cherty lammellae. On the other hand, the igneous rock was minutely subdivided and the fragments included in calcite from the lime. The resulting rock almost defies classification. The fragments which may be single crystals of the original rock or small fragments with numerous crystals, are greatly corroded also. About three hundred feet of this tuff overly the limestone. So far as appears from the east, the next step might have been the final one in the active history of the volcano, for the upper three to four hundred feet up to the cones and craters on top is covered with a vast sheet of rhyolite with free quartz which is more or less plainly visible to the eye. Passing now to the summit, the attention is held by a remarkable panorama. Evidently the axis of eruption rather closely correspond with the line of fault and so the declivity is very steep—in places almost sheer several hundred feet to a narrow valley which plainly displays on the opposite slope the up-tilted edge of the limestone in a fault entirely similar to the one which we have just past. Above it still to the westward is a series of hills of rhyolite springing from the fracture on the down throw side. But as we descend the ridge we discover much of buried history. The rhyolite which was the last phase of eruption did not follow directly the explosive stage represented by the andesite tuff but, probably after a period of repose, there had been more than one outflow of trachyte and trachyte pitchstone. These flows extend throughout the valley and to the south are seen underlying minor rhyolite masses. From the plagioclase-bearing and quartzless andesite to the acid rhyolite was a long step but this is partly bridged by the trachyte interval showing that mountains may grow old gradually if not gracefully. But there have been other episodes in the history we seek to follow. The crater during trachyte time must have been near its present site for a great boss of brown trachyte pitchstone still rears it head to the southwest of the crater never having been quite concealed by the flows of rhyolite. To the south of this peak the rugged vertebral column of the range is transversely cut by a dark dyke of small dimensions which, though greatly altered may have been andesite. Its strike suggests that it may have been derived from the great boss protruding from the western face. This rock compromises matters by leaving out the feldspars entirely and may be called a magma basalt or limburgite. It thus appears that the mountain made sundry attempts to restore its youth but its hoary summits attest the victory of the acid series.

At the very summit just south of the highest peak is an oval crater walled on all sides. Its longer axis is about 400 feet long and extends south east, while the shorter diameter of the ellipse is 250 feet measuring in both cases across the top. To the north east of the highest peak is another depression of a crescentic form which probably is also an old crater.

Now passing west to the opposite side of the valley we encounter the same sequence of limestone and shale strata as that on the eastern side of the main range. Near the bottom is a shaley stratum which is quite fossiliferous. Some little distance above this horizon is another of perhaps twenty-five feet with still larger fauna. As we ascend the evidences of life are less profuse being chiefly corals of which massive reefs occur at various horizons. Toward the top the evidences of metamorphism increase till the top becomes compact flint. There is no such interpenetration of the superincumbent rock as in the corresponding situation on the eastern side for the flow is a brown rhyolite. The latter rises to the height of several hundred feet above the top of the lime only to drop away rapidly to the west. At a point some two or three miles further south a section across the axis above desribed indicates that there was much less of igneous outpour but the disturbance is particularly well shown as also the metamorphism of the acid member. The diagram (Plate XI, Fig. 5) illustrates the situation.

Ideal Section through the axis of uplift south of Limitar mountain. 1. Trachyte crater. 2. Laminated margin of trachyte. 3. Porphyry about the margins. 4. Brecciated contact zone. 5. Massive limestone. 6. Shale with Productus cora. 7. Quartzite (20 feet). 8. Shaly limestone with Spirifer camerata. 9. Quartzite passing into the next. 10. Mica and hornblende schist with quartzite bands and phases. 11. Granite. 13. Diorite intrusive (paramorphic). 14. Talus conglomerate in or near the crater.

3.

MOUNT MAGDALENA AND THE BASIC ERUPTIVES OF THE MAGDALENA DISTRICT.

With Plate XII.

The general geological conditions of the Magdalena mountains formed the subject of an earlier paper to which reference is made throughout the following paragraphs.[1] The present paper is devoted to an area immediately adjoining the range on the north and west. It will be recalled that the Magdalena mountains form a compact range extending nearly north and south for a distance of about twenty-five miles and separated from the Rio Grande at the north by the Socorro range. The distance from the river is from fifteen to twenty miles. The mountains rise rather abruptly from the plain some three thousand feet or to the elevation of ten thousand feet above tide. Its northern portion is formed along a fault line extending from the central peaks, forming a monocline with a dip of about forty-five degrees in a direction twenty or thirty degrees south of west, exposing the carboniferous limestones on the western slope and the underlying metamorphic granite and quartzite on the more abrupt and irregular eastern slope. Toward the northern end the limestone has been removed by the effect of a secondary eruptive which has served to dislocate and fault the limestone series very extensively and to thrust it westward obliquely across the range at a point north of the Graphic property.

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[1] The Geology of a Typical Mining Camp in New Mexico. American Geologist, Vol. XIX, No. 4.

North of the Magdalena range the effect of the same orographic line of weakness or fault which made the range proper was felt at a later period and formed the axis of an extensive series of trachyte eruptives. The central portion of the range was the theatre of enormous eruptive activity during the earliest or andesite period. Two craters of this age remain, known respectively as Big and Little Baldy, the first situated at the junction of the southern with the middle third, and the second at the junction of the northern with the middle third of the length of the range. The northern crater, or Little Baldy, is still quite well preserved and the walls of the crater proper expose successive flows of andesite, andesite tuff, and aphanitic phases of the same material. From this crater a most extensive rift seems to have been formed to the northward along the western faulted margin of the stratified rocks of the range, from which fissure, as well as from the crater itself, enormous masses of basic lava flowed to the north and west. Other dykes and flows in different directions intersect the region. It may be said in a general way that, as a rule, wherever these dykes penetrate or influence the limestone series there is a tendency to segregate copper, silver and lead, while in other instances, where the contact is with acid rocks, the selveges tend to carry gold. It is rare to find gold not directly or indirectly associated with these basic eruptives.

South of Little Baldy and connecting with Big Baldy is a series of andesite dykes and bosses, a result of which the limestone has been displaced eastward into the Water Canon region where lead, copper and silver are collected, while near the crest, in dykes of felsite penetrating the andesite, gold has accumulated in appreciable quantities. Andesite areas which are evievidently the offspring of Big Baldy give rise to the well-known properties now being developed in the south end of the range. These are immediately associated with the andesites at the foot of Timber Peak, a lofty mountain east of Big Baldy.

On the west side of the range southward from Little Baldy, and extending to the west, north-west and south-west at a gentle inclination for many miles, is a very extensive system of acid flows which seem to have been derived from a fissure or system of fissures somewhat to the westward of the older andesite axis. These flows are of trachyte, obsidian, trachyte tuff and rhyolite. The obsidian is often black and is not infrequently found in brecciated fragments the later or rhyolite flows. Enormous erosion has operated to remove a great part of the flows and to carve the remainder into ribs and butte-like outlyers. The trachyte now seems originally to have extended northward and eastward to the very foot of the range, but this portion has been nearly entirely removed by subsequent erosion, leaving a series of low mountains or buttes at a distance of about a mile from the western foot of the range proper, while the valley in which are situated the towns of Kelly and Magdalena, as well as the Graphic and Iron Mask smelters, intervenes. Two of these isolated hills are prominent and well known landmarks, Elephant butte being the southern and Mount Magdalena the northern. These two are essentially similar in structure and form part of the great overflow which can be traced far to the south-west.

Mount Magdalena (Plate XII) owes its name to a remarkable patch of talus which is circumscribed by oak shrubs forming the perfect outline of a female head. This figure presents itself to the approaching traveler from the east and has been embalmed in the usual myths and legends. In spite of its apparently trivial nature, it seems to have remained practically unchanged for over 300 years, in fact, from the time of the arrival of the Spaniards, whose devout imaginations saw in its pathetic expression the indelible impress of the contrition of the Magdaline. Indian superstition found it impossible to pursue even the implacable duty of vengence under the placid eyes of the lady Magdalena and the spot became a place of refuge.

A special interest therefore attaches to this mountain, whose eastern slope rises abruptly from the valley, though the integrity of the escarpment is injured by a considerable frozen cascade of trachytic lava that curls over the brow of the mountain. It may be that some part of the mountain was the theatre of volcanic activity during the trachitic period but no adequate evidence is at hand to support that view. The base of the mountain is composed of brown and gray andesite to the hight of about 350 feet above the valley. Presumably this is a part of the great flow dating from the time of the eruption of Little Baldy and the extrusion of the great sheet of andesite and other basic eruptives in the region. The same rock crops elsewhere in the valley and we may ascribe the greater hight to which it rises here to the protection offered by the capping of later lavas which the ages of erosion have not sufficed wholly to remove. The andesite is not freely visible, being generally covered by the talus, thus it happens that its possible metallic resources have not been exploited, though the inevitable prospector has recognized the rock as similar to ore-bearing rocks elsewhere and burrowed into the veiny portions at various places about the mountain. The first deposit above the andesite was evidently of an explosive nature and was probable at or near the beginning of the acid period. It consists of banded trachyte tuff containing fragments of the subjacent andesite and also irregular pieces of dark obsidian like that which follows. Some of the pebbles are rounded and it may be suggested that the beds have been deposited during a period of intermittent aqueous flows and explosive eruption. The average thickness of this flow may be about 200 feet. Next above this, and forming evidence of a more placid type of eruptive activity is a bed of impure black obsidian. The lower layer of the obsidian contains fragments from the tuff, while the upper merge into the trachyte. The obsidian is in some cases porphyritic with crystals which have so far decomposed as to baffle identification but are probably sanadin. Similar beds are seen at various points further west. Above the obsidian is an extensive flow of trachyte in which in some places flowage phenomena bear record of its motility while in others it seems to have crystalized quietly in situ. Quartz trachyte passing into rhyolite is apparently found near the top of the series here as elsewhere. The presence of the explosive type of lava might be taken as evidence that the mountain was itself the theatre of eruption yet such flows often extend many miles and we have found a curious obsidian breccia in a trachyitic or rhyolitic magma at Texas Spring at the distance of at least six miles from a possible source.

Magdalena mountain stands, therefore, as a natural dissection giving a vivid conception of the earlier geological conditions of the region. Passing now to the region immediately north of the main range, we encounter a series of trachytic eruptives of which "Nipple Mountain" is the first and others continue the series to the extensive trachyte crater of Bear Mountain. To the east of this range the Carboniferous limestone lies in the floor of the plain instead of being tilted as in the Magdalena range. Small quantities of lead are found in the veiny and faulted limestone and dykes of "felsite" apparently of the trachyte age passing westward into the great andesite region north of the town of Magdalena· seem to have filched the lead to fill in these east and west veins. This andesite area or region of basic eruptives is interesting as probably forming a part of the product of the first Magdalena eruption and probably contains more than seventy-five square miles and may be much more extensive. It includes the Cat Mountain Camp and extends northward perhaps ten miles, while to the south, as already seen, it is for the most part covered by the later acid eruptives. The area is circumscribed to the east and north by the trachytes of the Bear Mountain series and on the west by the southward extension of the Gallinas to the Tres Montosos. At many places trachyte and rhyolite patches remain in situ above the andesite and dykes of felsite and trachytic material cut the rock in a north and south direction, These dykes very commonly carry small quantities of gold and though most of the mines opened have been in very low grade ore the possibility is not excluded that valuable accumulations may occur. It has already been mentioned that in the same area the east and west veins seem to carry lead and the theory is offered that this is due to the fact that dykes in this direction may be in communication with the limestone region to the eastward. The lead is chiefly in the form of galena but, in several cases, a variety of vanadium compounds occur, especially in proximity to the north and south dykes. Several gold properties have been quite entensively worked but none of them in a way to really explore the dykes to an adequate depth.

The whole area north of Magdalena to the Bear Mountain is of the same general character, while the latter seems to be the product of an enormous trachyte crater from which vast sheets have flowed in all directions covering a large area south of the Rio Salado. North of the latter is the margin of the great Cretaceous region of the Mount Taylor district which has been insufficiently explored along the southern margin.

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*THE GEOLOGY OF THE SAN PEDRO AND THE ALBUQUERQUE DISTRICTS.

By C. L. HERRICK,
President of the University of New Mexico.

The following pages are the results of a reconnaisance of the area covered by the so-called San Pedro sheet of topography issued by the government and a corresponding area lying west of that district. The country was visited by wagon and no instrumental work was done, distances being read by odometer and elevations by barometer. While a large part of the area has been personally visited and a great deal more material has been collected than can be made available at this time, it seems best to issue these notes as a guide to further work. It is to be expected and hoped that fuller details will be gathered and that the conclusions here reached may be modified by more extended comparison with adjacent parts of the territory. No attempt is made to touch upon the mineral resources, as this subject may be made the basis for a distinct paper. The paleontology and petrography are well under way but it was not thought wise to anticipate the fuller description of the final paper. Much of the area here described would be called a desert in eastern America while other portions are well-wooded and provided with flowing streams. In general, all but the lava beds is capable of supporting cattle and sheep. The southeastern portion is still well timbered. The means not being available to engrave a geological map the accompanying sketch is provided as a guide to the reader. For other contributions to the geology of New Mexico and the particular region under discussion compare a series of articles in the American Geologist, Sept., 1898, April, 1897, and July and Oct., 1898.

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I.

THE AREA WEST OF THE RIO GRANDE.

The triangular area between the Rio Puerco and the Rio Grande is occupied by a nearly level mesa between 700 and 900 feet higher than the river at Albuquerque. This field is nearly level but inclines to the southeast with the inclination of the strata composing it. The dip is apparently not more than ten feet to the mile. The mesa is about three and three-quarters miles wide at a point opposite Albuquerque and increases toward the north as the two rivers diverge. Nearly west of Albuquerque is the group of recent volcanoes previouly described.[1] The cones lie on the eastern margin and consist of a group of three major and as many smaller outlets. The three larger craters rise to about three hundred feet above the mesa or one thousand feet above the river. The material is a dark basalt which was emitted in small amounts intermittantly. The upper surface is vesicular and exhibits the usual appearance of a thin sheet which has cooled rapidly. It extends to but a short distance on the west over the level mesa but extended much further eastward, spreading over the somewhat lower levels in a sheet not generally more than 20 feet thick. It formed a lobed and irregular area which has been little eroded since its outflow. The materials underlying are, so far as can be seen, the same as those forming the mesa and not those of the river valley, though it appears that there was some erosion before the eruption, perhaps by a flow of hot water as in other cases in this neighborhood. This group of cones is only one of a series of basaltic post-tertiary volcanoes which can be traced along the entire length of the Rio Grande in New Mexico.

Professor R. T. Hill has described the later volcano flows of New Mexico in general terms in the Bulletin of the Geol. Soc. of America, III, p. 98. In concluding this paper he says: "It is also evident that eruptive activity has occurred in the Texas-New Mexican region from Cretaceous to the present time, and at least three well-defined epochs are at present recognizable which may serve as guides to future observations, viz:

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[1] Geology of the Environs of Albuquerque, American Geologist, July, 1898.

1. The Austin-Del Rio system, or Schumard knobs; ancient volcanic necks or laccolites bordering the Rio Grande embayment, begun in later Cretaceous time, the lava sheets of which have been obliterated by erosion.

2. The lava flows of the Raton system, which are fissure eruptions of Tertiary time, and which are only partly removed by erosion.

3. The cinder cones and lava flows of the Capulin system, which are late pleistocene and which still maintain their original slope and extent."

The geological structure of the plateau is not a little perplexing. The upper part of all the exposures seen for a thickness of over 50 feet is composed of a finely stratified sandstone and pebble series. In places this is indurated or cemented to form a crag, while in others it is quite loose and friable. The color at a distance is grey in evident contrast to the brown or red of the lower 50 to 75 feet exposed. The latter is a mass of finely stratified clay and fine sand without the pebbly layers. At the summit of the exposure is a band of marl varying from 10 to 25 feet thick with beds of charcoal carrying plant remains. This seems in every respect to be similar to the marl previously described as forming the upper layer in the river valley, though there is a difference of over 400 feet in altitude. It might be supposed that the lower marl was derived from the older or that both had a common origin. This marl is well seen on the western exposure of the mesa facing the Rio Puerco where it extends to a point far to the north of the position of the craters of the eastern slope. It is also seen on the face presented to the Rio Grande a short distance below the craters and data are wanting to determine whether it underlies the flow. It is not found underlying the flows from the craters in the same relative position to the mesa northwest of Bernalillo, nor does it appear under the lava sheets which form the wall of the canon next north of this mesa near the town of Santa Ana. The exposures last mentioned apparently are of the same age as those opposite Albuquerque yet there has evidently been an extensive erosion of the area separating them for the sandy layers below the lava are in places exposed for 450 feet. They consist of grey and red sands with only occasional indurated bands and are covered with sheets of vast extent but usually not more than twenty five feet thick. The thicker portions evidently were nearer the volcanic centre as the sand and clay below has been burnt and indurated and has a bright red color.

The prevailing color is reddish, especially in the lower parts. An exposure in the mesa now in question to the west of Los Corrales and perhaps five miles north of the Albuquerque flow has the same red color but is here capped by the marl which is not encountered beneath the sheets north of Bernalillo. The entire region north of Bernalillo extending west to beyond Santa Ana and extending east and north along the west bank of the Rio Grande to beyond the Indian village of San Filipe is occupied by this formation and is covered by vast sheets of basalt from craters lying to the northwest. One of these has been dissected for examination by erosion and was described as the Bernalillo volcano in a previous paper.[1]

Careful search has so far disclosed no organic remains beneath any of these flows though many miles are exposed to view. The sheets are at various levels and suggest the probability of successive superincumbent layers but, so far, there seems to be no evidence of more than one general period of eruption, for most of the flows at different levels can either be traced to different craters or are connected with other parts of the sheet by declivities or separated from them by displacements of later age. A great deal of base-level undermining is going on and even the small streams at once wear down to the general lower level. There are a few sand dunes upon the western margin of the mesa and it is likely that the major part of the local accumulations here and there found on top of the marl is of the same origin. The mesa proper is bare of trees but supports good grass as the marl is a water-bearer. To the north as the valley of the Jemes arroya is approached and the marl has been removed by extensive erosion, the surface is rolling and the sandy soil supports little beside a scanty growth of juniper. The weathering and erosion of the sandy layers leaves a very characteristic debris of dark flint and jasper as well as fragments of pertified wood.

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[1] Amer. Geologist, July, 1898.

The valley of the Rio Puerco, about three miles wide at a point west of Albuquerque, is about 725 feet deep and its upper course is carved out of Cretaceous sandstone and shales. On the west side these strata reach the present river bed at the so-called Punta de la Mesa two miles north of the little town of San Ignacia which is north-west of Albuquerque. The river here seems to occupy the site of an anticline, the strata to the southwest, the exposures of which diverge from the river, dip to the southwest by a very small angle, while those on the opposite bank dip to the southeast. In fact, this line of flexure crosses the strata a few rods from the river, which doubles round the point. The most complete exposure at this place is about 325 feet high, the lower 250 feet or so being of dark fissile shales with sandy layers and concretionary and gypsiferous phases. The upper 75 feet or less is of a variable reddish or yellowish sandstone with local white sand deposits. The continuity of the series is much broken by minor faults so that neither the position or dip of the strata is constant over large areas and the lithological characters are also quite inconstant. The upper nodulary phases of the sandstone in some places are quite fossiliferous. Only a short distance below the bottom of the sandstone layers is a more or less constant band of carbonaceous shale which in some places becomes a lignite. Still below this is a zone in which occur large numbers of calcareous concretions. Each of these when broken reveals the presence of a fossil, generally one of the two fine Goniatites figured later, while a few small fossils occur in the shales. To the north of the point the escarpments of the rocks described continue to flank the immediate valley of the river for many miles. On the east side the same series is repeated by faulting and reappears to the east in successive ridges. In these exposures it often happens that the yellow and irregular banded sandstone is substituted for by massive white sand for shorter or longer distances. Above this layer is a conformable bed of yellowish loamy clay which is very finely banded and homogeneous. To the east the inclination of the faulted blocks becomes less, those near the river having a dip of about five degrees. Near the eastern margin of the valley the strata are nearly horizontal and the Cretaceous strata describe above disappear below the surface. Their place is occupied with bands of sand which have the texture of the upper loamy layer mentioned as overlying the Cretaceous near the river. The color is variable however and the strata are so disturbed that it cannot be said certainly that the two are part of the same system. We incline to that view and think that the red sands which appear in the eastern wall of the valley, inclined at a barely perceptible dip, are of the same age as the outliers in the eastern part of the valley and these in turn of the same age as the remnants of fine material on the upper surface of the Cretaceous near the river.

At present we can only conjecture that these sandy beds are of Tertiary or Pleistocene age.

2.

THE SANDIA MOUNTAINS.

This range is the most conspicuous mountain group visible from Albuquerque, directly east of which it lies at a distance of from five to eight miles. The highest point of the range is about 10,000 feet above the sea or a little more than 5,000 feet above Albuquerque. The mountains are part of a great monocline which extends along the left bank of the Rio Grande to the south. This monocline passes into an anticline by degrees, as the Ladrones, Limitar Mt. and Socorro range contain the same formations dipping to the west on the right bank. The Rio Grande may be said to occupy the axis of an anticline or, better still, an axis of disturbance which in various parts has resulted in different geologic structures according to circumstances. These disturbances were inaugurated, so far as the geological record shows, in pretertiary time by the series of andesite eruptions and have continued through a trachytic and rhyolitic period and in post-tertiary time have been supplemented by the basaltic flows now so prominent in the topography of parts of this district. The Sandia range is separated from the continuation of the uplift to the south by Tijeras canon, itself marking, as we shall see, a transverse axis of disturbance. The length of the range is about 20 miles but the deflection of the valley of the Rio Grand to the eastward in the northern part of our sheet causes the western escarpmeut to bear off in that direction and, this being in the direction of dip the height falls off rapidly in this part toward the north. The crest of the range is everywhere a band of Carboniferous limestone 400 to 600 feet thick. The maximum thickness is not preserved, so that the upper horizons of this formation are better seen in the nearly horizontal beds to the east.

The dip being from eight to twelve degrees to the southeast those peaks lying most to the westward are, of course, highest. The age of the limestone is abundantly attested by the fossils, while below them is a vast series of metamorphics the age of which it is impossible to more than conjecture. These metamorphics are of two groups which are distinguished by their lithological character and conditions of formation though they may be practically contemporaneous. In general, the limestone is underlaid by a mass of quartzite of varying thickness. This, where the metamorphism has been slight, is obviously of a sedimentary nature having conglomeritic phases. In other places this quartzite has been perfectly transformed into a granite or gneiss. It thus happens that in many places the limestone reposes on a crystalline granitic rock. In other places the granite is more than fifty feet below the base of the limestone. The second series of metamorphics is found at certain foci of uplift. One such focus is seen in the foot hills to the west of Sandia peak, the high mountain at the north end of the ridge, another just at the mouth of Coyote Canon at the east end of the transverse axis of uplift which forms Tijeras Canon. Another and more important one occurs further south in a similar relative position at the mouth of Canon Largo and forms the geological cause of the Hell canon mining district. These foci of uplift and metamorphism are evidently metamorphic centres also. Taking, first of all that which occurs south of the mouth of Coyote canon, we find here that there is a boss-like area of quartzite around which the remnants of the limestone have clung and these dip in all directions away from the centre. To be perfectly accurate we should say rather that these points have not settled as much as the adjacent parts for here, as elsewhere under the like conditions, the area of greatest plasticity has been a little away from the line of greatest elevation. In this same area too there is the evidence of special secondary metamorphism as there are masses of schist of the most various kinds as well as paragenetic diorite.

The larger focus west of Sandia peak is of essentially similar character though there are no remnants of the superposed lime. The rock has become a schist of various species and is intersected in various directions by large dykes of quartz. The most highly metamorphic phase is diorite and the circumstances are such as strongly to reinforce the theory long since propounded by the writer on the evidence of Lake Superior lithology that the diorites are paragenetic and not independent igneus intrusives. No core of basic eruptive is exposed, though it may exist. It is probable that these metamorphic areas are old and that they may under favorable conditions produce some mineral. The third of these foci in the Hell canon district has been quite carefully studied and the results are given elsewhere. Here the metamorphism has produced large dykes of quartz and diorite, the former carrying some free gold. A little depth however soon converts such metal into sulphides and the present prospect is that sufficiently deep mining may yield some copper in the form of glance and pyrites.

The western slope of the Sandias being quite abrupt, the face is cut by short canons in the granite with deep dells and recesses in which there grow, especially near the summit, a number of plants evidently strays from the far north. The eastern slope, on the other hand, being quite gradual permits the mesa flora to rise to near the summit. A deep canon in the north end known as Placitos canon serves to collect the water from the northern part of the range and forms a most fruitful valley.

The Tijeras canon on the south cuts the range abruptly off and the whole area from this canon to a point some miles south of Canon Largo, a distance of at least ten miles, has dropped out of conformity with the portion of the range both to the north and to the south.

The cause of the fracture in the case of Tijeras canon is not far to seek but consists in a massive upthrust of a quartzose rock which passes obliquely across the range from southwest to northeast, terminating at the western end in the neighborhood of Coyote springs and at the eastern extremity in the vicinity of Whitcomb's springs. It is a curious fact that the opposite ends should give rise to nearly the same conditions, the springs in both cases being highly mineralized. At Coyote especially the springs are highiy carbonated.

The following is the result of the analysis of a sample of Whitcomb spring water by Prof. Randolph W. Tinsley, of the University of Mexico:

Sodium Chloride, grains per gallon	.1927
Calcium Sulphate, grains per gallon	1.4360
Calcicum Carbonate, grains per gallon	8.1896
Magnesium Carbonate, grains per gallon	1.5188
Total	11.3371

The width of this axial dyke varies from 25 to over 50 feet, and it is flanked by metamorphic rocks like hornblende and mica schists and diorite. Near the eastern end of the canon the schist and diorite come into close proximity to the limestone and the latter is greatly faulted and dislocated. At the east end of the canon the strata of the Jura-triassic and Cretaceous abutt upon the Carboniferous, so that the town of Tijeras is on the Jura-triassic area.

3.

THE AREA NORTH OF THE SANDIA MOUNTAINS.

From the northern portion of the Sandia range there is a strong spur or isolated uplift composed of granite and schists intersected with dykes of diorite and of quartz. This spur projects westward toward the river and gives rise to springs and streams of beautiful water. This area has not been sufficiently studied but is evidently the focus of iocal metamorphism as described above. To the south of the spur a small portion of the same formation as that which underlies the lava beds to the north and west of the Rio Grande protrude through the river gravels and consists of the same red detrital materials. Near the river in the neighborhood of Alameda is a deposit of pumice evidently from one of the craters in the neighborhood of Bernalillo. To the north of this place the supposed pleistocene crops in the river bed as it does at several places even further south. It also appears in the hills and seems to be greatly commingled with the river gravels. North of the Sandias to the river and Galisteo creek and eastward to the Jura-triassic area east of Thornton the surface is irregular and is worn by erosion into deep gullies. The material is chiefly unindurated sand and crag with shaly layers. This may, in all probability, be referred also to the Pleistocene. In fact, evidence that this is the case is found in the neighborhood of the little Indian town of San Fillipe where an outlyer of the lava on the east side of the river forms a small isolated mesa about 100 feet above the general level. The river gravels are seen on the eastern aspect rising half way to the top and enabling one to observe the contrast. It would appear that the exposed soft materials have eroded faster than the same strata on the west side of the river where protected by the lava as is also the case in the area opposite Bernalillo on the west side of the river and south of the lava. This eroded country is denominated "the bad lands," but has no relation to the *mal pais* resulting from the breaking down of the lava flows met in many parts of the territory. Going east, the country rises to about 525 feet above.

the river. Here is a bed of marl and crag reminding of the superficial layer opposite Albuquerque. The whole area south of Thornton seems to be similar till the Jura-triassic area at Galisteo creek west of Cerrillos is reached. At the very north end of the mountains the foot hills seem to be of Cretaceous and Jura-triassic but the disturbances have been so great that little has been done in unravelling the complicated relations. A deep canon cuts far into the range from the north, at the mouth of which is the Mexican town of Placitos. The canon is due to the extensive fault in the Carboniferous limestone by which the lime after dipping from the crest to near the general level on the west side of the canon, reappears on the east side in a precipitous cliff of perhaps 600 feet. The valley is cultivated for a number of miles and apparently contains Cretaceous strata. At the extreme northern limit of the eastern wall of the canon there is a series of springs and a very confused area. It here appears as though the limestones of the Carboniferous were followed with only slight disturbance by the beds of the following formation. A limestone occurs which contains fragments of Carboniferous lime together with their fossils commingled with fossils of a different habitus. The remains are poorly preserved and no decision can now be reached as to their age. Among these beds are others composed of red granite fragments, forming a small-grained conglomerate. Red sandstone and shales seem to follow, to be in turn succeeded by banded quartzite and other beds of shale and sand and still other strata of quartzite. The strata all dip to the east and it is hard to determine whether the series (here regarded, on lithological evidence alone, as Jura-triassic) is quite thick or whether it is frequently repeated by faulting. East of these exposures there is a very prominent ridge with its abrupt escarpment toward the west offering the following section: at the base at least 200 feet of red sandstone with irregular layers of vesicular limestone, then 85 feet of saccharoidal white sandstone and on top a band of 15 to 20 feet of yellow limestone. This section is crossed by the road to Tijon where are saline springs. It is probable that the upper part of the section is Cretaceous. The region to the east of this ridge is probably Jura-triassic. Passing south, there are low hills with gypsiferous shales and gray and white sandstones nearly to La Madera which seems to be upon a plateau of limestone, broken in places by granite or other igneous rocks. From San Antonio to San Antonio is a Cretaceous region and along the roadside we find about 50 feet of shales with lenticular masses of limestone topped by an eqal amount of freestone. Between San Antonio and Tijeras the boundary between the Cretaceous and the Jura-triassic is crossed through here the disturbed stratigraphy is difficult to unravel. The valley of the creek from "Uno de Gato" to Alamillo and southward is occupied by the red Jura-triassic. Ascending the creek we encounter horizontally stratified beds of clay possibly of Pleistocene age reposing on older tilted rocks.

4.

CARBONIFEROUS AREA SOUTH OF TIJERAS.

On the east side of the range, south of the town of Tijeras is a region consisting chiefly of rough and rolling country quite densely timbered. Passing south of Tijeras, which is situated on the Jura-trias area, about half a mile, the contact between the Jurassic red sandstone and the Carboniferous limestone is clearly seen. The contact is along a sharp fault extending approximately east and west—a line which may be followed at intervals for many miles. The upturned edge and adjacent parts of the lime are metamorphosed and filled with segregated silica. The dip is to the southwest in the immediate vicinity of the fault while the Jura-triassic on the opposite side dips northeast. To the south of this fault the country is wholly made up of Carboniferous strata. The series is nearly horizontal with slight variation in different directions from the horizontal plane.

Although there seems to be no place where the entire Carboniferous series is exposed from bottom to top the following section is no doubt nearly complete and embraces over 600 feet commencing with dark fossiliferous limestones such as are elsewhere found near the base of the series. The fossils are such as Productus cora, Spirifer opima, Martinia concentrica, etc. The section is about as follows:

First, 225 feet of dark, bedded limestone, followed by 50 feet of shales, then 150 feet of gray massive limestone on which reposes about 25 feet of reddish or yellowish sand-stone. Then follows 100 feet of limestone with a thin bed of shale and a few feet more of lime making up an additional twenty feet. Then follows 25 feet of sand-stone and 25 feet of lime to the top of the exposure. Carboniferous fossils may be found to near the top though it is possible the very upper portions may contain representatives of a Permean fauna. It will be noted that this section contains sand-stone members near the top not seen in sections apparently as complete further east. It is probable that the present section actually reaches higher levels than the latter and that a certain part of the limestone series is below the present section and is to be added to the total thickness.

Passing eastward the strata become practically horizontal and the country more level. The fault line between the Carboniferous and the Jura-triassic is well seen at the little town of De Vaca about two and a half miles east of Tijeras. The limestone and the sands of the Triassic both dip to the northwest but in no place were the two seen in conformity. At this place it is the upper part of the Carboniferous that emerges and it is here filled with bryozoa and a narrow horizon is distinguished by being almost made up of small foraminifera of the genus *Fusulina*.

The Carboniferous extends eastward and apparently covers the entire rolling country to the valley occupying the eastern part of the sheet. At Sedillo it is well exposed and is still nearly horizontal. Further northeast it seems to be uplifted so that the underlying quartzites are exposed two miles northeast of Sedillo. This area is covered with a sparse growth of cedar and pinon and seems to be available farm land where ever irrigation is possible.

An irregular line extending north and south along the eastern third of the sheet is the axis of uplift occupied by the mountains of the San Pedro group, which are, beginning at the south, first, South Mountain with its westward extension of granite hills, which we may call the San Antonito mountains. Next north is the San Pedro peak with its foot hills. Then the Ortiz group and, finally, north of the Galisteo creek, the Cerrillos range. In all these, except the San Pedro mountain, the greater part of the uplift seems to be of granite of the metamorphic series. The Carboniferous limestone skirts the southern border of South Mountain and extends nearly to San Antonito and encloses the area of Cretaceous and Jura Trias extending from Tijeras to the latter place. Directly west of South mountain there is preserved a bold escarpment of the Carboniferous. Here the granite is exposed from time to time below the Carboniferous but the lower 175 to 185 feet is partly covered and partly obscured by an interpolated intrusive. (A section of this rock shows it to be an orthoclase porphyry with hornblende and diallage?) The upper part of this portion seems to be an earthly limestone. This is followed by ten feet of fine shale such is commonly found within a hundred feet of the quartzite, and this is followed by a fossiliferous shale with the characteristic faces of the lower member of the series. Productus *Spirifer opima* and *Martinia* are abundant. Seventy-five feet of dark bedded lime follow, after which the lime has a vescicular character with nodules of chert for one hundred and ten feet. The next 120 feet is more homogeneous and of a gray color and has a large species of Athyris as the characteristic fossil. The upper twenty feet of this member inclines to be shaly with a yellow color and is filled with bryozoa. At this level too is a belt of Fusulina limestone. The remaining forty-five feet is made up of massive dark gray lime with bryozoa. It is evident that this section lacks the upper portion and the sandy beds noticed in sections further south and west are here absent.

From this exposure to a point west of the Ortiz mountains the limestone is the country rock, though it nowhere rises to so high a level as here. It apparently extends uninterruptedly between South Mountain and San Pedro Mountain and not far east of the town of San Pedro it is sufficiently charged with lead to give rise to productive mines. The ore concentration may be ascribed to the influence of the San Pedro crater and affords a beautiful illustration of the relation of metamorphism from local vulcanism to ore assemblage. On the west the limits of the Carboniferous are marked by an abrupt or even precipitous drop to the area of the valley occupied by a stream flowing north into the Rio Grande north of Bernalillo. Here the red sands and shales ascribed to the Jura-triassic lie in confused dip, the fragments being faulted in various senses. The Carboniferous again appears in irregular patches on the west side of the stream nearly horizontal in position and obviously forming fragments once continuous with the Sandia block. The whole area in this sheet east of the mountains and south of the Galisteo creek is an alluvial valley and seems to be underlaid by the Carboniferous and possibly some of the later strata. It is the only part of this sheet that promises to afford artesian water and should such wells prove successful this beautiful valley will become the garden of the territory.

5.

THE GEOLOGY OF SOUTH MOUNTAIN.

The clustre of peaks by the above name is at the southern end of the series of rather isolated mountains lying east of the Sandias and faces the extensive valley forming the eastern part of the sheet. From this valley it rises abruptly and the granite core soon breaks through the fringe of sedimentary strata at the base, and rises in bare crags to over 8000 feet. A lobe of the valley to the eastward passes westward immediately to the south of the mountain giving to it an isolated appearance from all directions, though to the west it extends in a series of lower hills of granite, schist and gneiss nearly to the town of San Antonito. About the eastern base there are perhaps a hundred feet of red sandstone which probably is of Jura-triassic age. These strata dip away from the main peak at a slight angle. To the west it is the Carboniferous limestone that skirts the base. These limestone strata extend far up the western foot hills and are much titled and faulted. The north and south valley or canon which separates the main range from the western foot-hills exposes a vast series of schists of great lithological variety. Occasional diorites exhibit the extreme of metamorphism but no true intrusives were seen. All portions of the range were not visited and it is possible that some intrusive outbreak was overlooked but in that case it must have been quite insignificant.

6.

THE SAN ANTONIO AREA.

The area east of San Antonio and thence to De Vaca is peculiar and in some respects unique. At De Vaca is a fault extending northeast which is in all probability the extension of the similar fault seen a short distance east of the town of Tijeras. The carboniferous lime is here abruptly cut off and the Jura-trias appears on the west side with a strong dip to the northwest. These strata appear in two ranges of hills to the northwest, beyond which the Cretaceous appears either following in normal sequence or, as is more probable, on the down side of another fault. The country in this neighborhood is very rough, the lower parts of the exposures revealing a dark carboniferous shale, at which horizon coal is occasionally mined, as is the case north of the cabins of Gutierez. The upper members are of a yellowish freestone capped with a more dense white sandstone. An irregular but rather continuous escarpment forms a bluff which is a conspicuous landmark from a distance whence the land ultimately slopes to the region about San Antonito, the interval being filled in with Cretaceous. The dip is generally north and northwest but is modified by at least one north and south dyke. The one in question is of peculiar interest as being probably the last remnant of a volcano that once existed about a mile east of San Antonio. At this place is a large amphitheatre of at least a mile in diameter bounded to the north, east, and west by the escarpment of Cretaceous just mentioned, on the south in part by a low hill of Jura-trias.

This amphitheatre is now a fertile valley but from its northern arc a dyke of basic igneous rock pierces the escarpment to the north which is affected by its forcible intrusion in such a way that it dips away from the dyke on either side. At this place the freestone is filled with impressions of a single species of mollusk. The exposure is as follows : gray, fissile, earthy shale, 75 feet, the upper part being carbonaceous and partings of flags occurring throughout; thin-bedded grey shales, 75 feet; sandy shale with flags, 50 feet ; freestone with fossils, 140 feet; crystalline white sandstone, ten to twenty feet.

Between this amphitheatre and San Antonio the series seems to be twice repeated by faulting and between the later place and Tijeras there is a series of hills containing the Jura-triassic.

7.

THE CERRILLOS AND ORTIZ AREA.

About six miles west of Cerrillos on Galisteo creek a narrow zone of the red Jura-triassic shales and sandstone outcrops. The dip is here east and northeast perhaps 25 degrees. A careful search discovered no fossils. North of the creek the Cretaceous strata rise to a height of about 375 feet above the track. The section at this place is as follows : 50 feet of red shale and sand capped with hard red sandstone, then 175 feet of white sandstone of varying consistency, 75 feet of chocolate shales with concretions in bands, followed by twenty feet of sandy white shales with a band of white sandstone about three feet thick below and a somewhat thicker one above, 30 feet of sands and shales and at the top 25 feet of indurated sandstone or quartzite with conglomerate. The base of this series may be Jura-triassic. Passing eastward, after what seem to be two partial repetitions of this section by faulting, we encounter a section with quartzite at the base which passes into white sandstone, then 20 feet of bluish black shale, a zone of red calcareous concretions and 25 feet of dark fissile shale and 15 or 20 feet of yellow sandstone. After crossing a deep valley the following section is encountered ; 115 feet of gray shales and thin flags with numerous Cretaceous fossils, covered with a sheet of about ten feet of what seems to be a basic eruptive rock similar to that covering a great deal of the region about Cerrillos.

This flow proves to be a characteristic lencite phonolite. From this point to the western foot of the Cerrillos mountains the same fossiliferous shales and flags occur in low hills. Essentially the same sequence occurs south of the creek. The region to the west and south of the mountains are cut by radial dykes which beautifully illustrate the way in which these dykes habitually occur. The intersected rock being in this case for the most part soft and easily eroded, the dykes are left as conspicuous walls rising several feet above the general level, and may be traced for six or eight miles continuously. They vary from two or three feet to twenty feet in width and the same dyke may vary greatly in this respect. The material, so far as can be determined without a section, may be an andesite but in the thicker portions it tends to be replaced by a felsitic material. This may be explained upon the supposition that where the local metamorphism was great the fused acid material expanded the original fissure by disintegrating the walls and, in some instances nearly or quite suppressed or obscured the eruptive.

The alteration phenomena in proximity to the dyke are quite interesting. In particular, the formation of chalcedony and jasper from the siliceous wall rock is plainly seen. The influence of the sheets of the same material, while less pronounced, is no less apparent, for the shales and limestone so covered have become flectuously lammelate and crystallized. The source of the flows as well as of the dykes is no doubt the south end of the Cerrillos mountains which are composed of a similar material. The northern part of the range is of granitic rock which may be later than the old phonolite nucleus. This region gives us the suggestion that the phonolites are probably post-cretaceous. To the northwest of the mountains, about three miles from their base, is a recent basaltic crater from which extensive flows of lava have spread to the west and southwest. Along the southern margin of this sheet there has been very extensive base-leveling erosion exposing from 50 to 75 feet of the soft strata beneath. In the vicinity of the mountain, along its western base such exposures are very instructive and give the surest clue we have so far seen to the age of the several intrusives. Here, for example, at the base of the exposure are 60 feet of dark, horizontal, Cretaceous shales intersected by nearly vertical narrow dykes of what looks like a basalt though much decomposed. The strike of such a dyke about two feet wide near the road to Santa Fe is N. 10 degrees W. Above these shales is a bed of crag and loose material over 50 feet thick. The bowlders at the bottom of this series are of phonolite similar to that of the mountains at the south end of the range. The whole is capped by 25 feet of recent lava from the adjacent cone. The basalt dyke referred to stops short at the top of the shales showing the upper loose zone to be of later date than the intrusive. The shales, which dip to the east at a distance from the mountain, become horizontal as they near the range and, near its base, dip to the west. We may assume that the phonolite uplift, at least the later part of it, occurred after the deposition of the Cretaceous and that the later deposits (perhaps Pleistocene) result from the erosion of the resulting materials. The extensive dykes radiating from the mountains and cutting through the strata may therefore be of the same age as the main mountain uplift. Though the northern and higher peaks of the range are of granite it is probable that this uplift is parasitic upon the basic eruption.

At Waldo, about three miles west of Cerrillos, at a point about a third of a mile north of the track, is a prominent mountain of porphyritic gray eruptive which shoulders its way through the dark Cretaceous shales. From this region a strong dyke extends southward and is apparently the same that intersects the coal workings of the Cerrillos Coal Co., near the breaker, and may be the principal cause of the special metamorphism which has transformed the bitumenous coal to anthracite at this place. This dyke is about twenty feet wide and is a prominent landmark. The other hills of the Cerrillos range between Waldo and the town of Cerrillos seem to be, for the most part, composed of the same basic eruptive as is the country to the northward nearly to the foot of the granite mountains of the northern part of the group. The country for two miles or more north of the town is broken and, while the country rocks seem to be basic, it is intersected with acid dykes that may be derived from the same source as the granite of the northern peaks. These acid dykes in a basic rock carry a small quantity of gold as is the almost universal rule under these circumstances. Extensive superficial prospecting has resulted in opening no important mines thus far. To the east the Cretaceous sandstones and shales occupy the surface for many miles and, in one locality a few miles east of Cerrillos, there is a considerable area covered with the silicified trunks of large trees—in short a buried and petified forest is exposed. The trunks are frequently only partially exhumed by erosion and protrude from the sandy matrix in a horizontal position. The Omera coal banks fourteen miles to the east and south of the railroad have at various times been extensively worked but at present the coal shipped by the Santa Fe comes entirely from the extensive mines at Madrid two or three miles south of Cerrillos. The detailed study of this interesting region is reserved for a special paper. The rocks are of Cretaceous age and consist of about 150 to 200 feet of alternating shales and sandstone. The higher layers are often of a yellow freestone not unlike the Waverly rock of Ohio in appearance.

The whole is much disturbed and faulted and seems to have been covered by a flow of basic material of varying thickness which in some place has given place to a crag of materials derived from the erosion of this sheet. Immediately above the anthracite is a thin bed of a black basalt-like intrusive that seems to have qeen injected between the strata or to have covered the roofing shales of the coal. It may be that this sheet is to be connected with the dyke above mentioned. It is a question whether the superficial sheet of phonolite (?) has had much part in the metamorphism of the coal though that seems to be the local theory. Passing to the south, the gray igneous rock assumes greater importance and occupies all the foot hills to the granitic or gneissic core of the Ortiz range. The Cretaceous bounds the mountain on the northwest and the entire western base is apparently occupied by the Carboniferous.

A deep valley separates the Ortiz from the San Pedro mountain, the former, so far as observed, being composed almost exclusively of granite rocks, while only the northeastern part of the San Pedro mountain is granitic. The latter will afford an interesting field for study as it is essentially an old andesite crater with more or fewer parasitic acid flows. The Carboniferous lies upon its southwestern flank and has been subjected to so great metamorphism that the lead content has been segregated and considerable mines of carbonate exist in the neighborhood of the town of San Pedro. The foot hills near Golden on the northwest of the range are of Carboniferous limestone also but in the valley separating San Pedro mountain from the Ortiz group is a tongue of Cretaceous sand and shale. The crater proper occupies the entire center of the San Pedro mountain, the rim being broken at the northeast at the locality of the Saint Lazarus mine and mill.

West of the Saint Lazarus mine a section of the wall of the crater is as follows: 200 feet of sandy and calcareous material highly metamorphosed and serpentinized. This may have been an earthy limestone with sandy bands. The dip is into the crater, i. e. to the northeast. Next is 100 feet of altered limestone like the lowest horizon, then a sheet of andesite aphanite lying conformably above the sedimentary and serving highly to metamorphose it at the contact. At this contact is a certain amount of copper stain which has excited the curiosity of the prospector. The dark band is visible for miles and has universally been called the "black lime" by the miners. Above the aphanite is a variable amount of acid rock—perhaps a felsite. The south and western rim of the crater are quite sharp and are essentially similar tnough more of the andesite is found in places. In the interior the andesite is more in evidence and is mixed with acid flows giving rise to the conditions for gold collection. As a matter of fact there is gold in the placer gravel within the crater practically everywhere. The contacts of the andesite and the acid rocks are also habitually auriferous and are worked to a considerable extent, the "Gold Standard" mine being quite well known locally. The northern wall of the crater is broken by a massive dyke extending north and south and other dykes extend in various directions into the surrounding country. To the east there have been extensive flows the sedimentary rock having been removed to a great extent and the important flows being of andesite and an acid "felsitic" material. In the vicinity of Golden there has been some extensive placer working, the results of which it is yet too early to ascertain.

The northeastern part of the territory, from a line passing through Raton and Las Vegas and thence southeast, is said by Professor R. T. Hill to have formed a part of the Tertiary continent and not to have been submerged since the Cretaceous. (Bul. Geol. Soc. Am. III, 86, *et seq.*) "The cities of Trinidad, Folsom, and Las Vegas may be considered as bench marks along the northern, eastern, and western boundaries respectively of this region, while Raton, Springer, Maxwell, and other points along the Santa Fé railroad between the Purgatoire, at Trinidad, and the Pecos are located upon it. The southern boundary is the superb escarpment of the Canadian Pecos valley."

"Everywhere is seen the grand result of profound erosion by which the overlapping formations (Dakota, Denison, and Trinity beds) have been stripped from the horizontal red beds, which constitute the valley floor, and has left standing in the valley numerous remnants of the plain in the shape of great circular buttes and mesas, such as El Corazon, The Gavilan, Mesa Rico, Mesa Redondo, the big and little Haarfando Mesa, Tucumcari, and others, every stratum of their red, brown and white beds being visible in horizontal bands for scores of miles."

"The erosion from top to bottom of the successive plains of stratification has partially removed more than 5000 feet in thickness of sedimentary strata."

a.

THE CARBONIFEROUS.

In the Rio Grande region of New Mexico the Carboniferous formation is remarkably homogeneous. It always rests with apparent conformability on a series of quartzites that form the transition into the metamorphic granites and gneiss below and the thickness of the quartzite often seems to depend on the amount of metamorphism to which it has been subjected. In some places the limestone seems to rest diretly on thė granite but these cases may be interpreted as instances of extreme metamorphism that have caused the qurtzite to assimilate to the granite. There seems to be every reason to suppose that the band of quartzite is of a different age from the granite as well as to believe that the granite itself is of sedimentary origin. The basal quartzite is usually from fifty to seventy-five feet thick while it may drop to ten or twenty feet. A few fossils have been found in the upper shaly layers but they probably belong rather to the shales which next follow. These shales are frequently highly metamorphic but are fossiliferous. The quartzite has conglomeritic phases with granitic and other pebbles. It reminds one by position and lithological character of the basal conglomerate lying under the coal measures of Ohio and Pennsylvania but no homology is suggested. The conglomerate quartzite is frequently the catch-basin for the leechings of the limestone and sand-stone above and accordingly is of some importance as a collector of intrusive ore. See account of the Caballo mountain ore in another place.

Immediately above the quartzite is usually a band of shale of about ten feet followed by perhaps 150 feet of fossiliferous limestone. It is in the shaly beds in this horizon that the most abundant fossils are to be found. Spirifer opima, Productus cora, Martinia concentrica, etc., are the characteristic species.

In typical sections this lime is followed by about twenty-five feet of conglomerate or sand-stone. There follows about three hundred feet of limestone which tends to grow lighter toward the top. This is not very abundantly supplied with fossils. It may be separated from the next member by a thin band of bandy shale. In many exposures the next fifty feet is the prominent portion of the series it being a specially massive and permanent band of limestone. The next 125 feet is fragile and contain Productus nebrascensis (?) and large Spirifers and a large Athyris as the characteristic fossils. Four to six feet of shale may occur at this point. About 25 feet higher is a peculiar greenish layer with a sandy tendency. Still 60 feet higher is a definite sand-stone layer often characterized by the presence of much feldspar in the sand. This band is about ten feet thick and is followed by about 100 feet of gray lime.

The sandy members are not very constant. The position of the zone of bryozoa and Fusulina bed is probably near the prominent bed of lime mentioned and, as this is often the apparent top of the series, the beds are frequently quite accessible.

The nature of the transition into the Jura-triassic is still obscure. . At the north end of the Sandia range is an exposure where the transition apparently can be seen. The extent of disturbance is however a drawback. So far as can be seen the base of the red series is formed by a curious bed of large-grained sand or fine conglomerate the grains being red granitic fragments. There is also a lime conglomerate. Then a band of lime in which is a fauna with a decided Carboniferous facies yet with foreign elements. In fact, the appearance is as though the Carboniferous fossils were in fragments of the Carboniferous limestone while the others were collected with the fragments and cemented together. A perfect specimen of Hemipronites cremistria with both valves was found. Awaiting the opportunity to collect added specimens the age of these beds must be left in doubt with the suggestion that they may prove the missing Permian. No fossils have so far been found in the red beds referred to the Jura-triassic.

A comparison with the section given by Captain E. C. Dutton from the Zuin plateau (Sixth Annual Report of the U. S. Geological Survey, 1885,) will show that the fragments of the Jura-triassic and Cretaceous encountered in this region are insignificant when compared to the great formations to the west, for 3150 feet are attributed to the Jura-triassic alone in that section. The work of correlation has hardly progressed far enough to make comparisons desirable.

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*NOTES ON A COLLECTION OF LIZARDS FROM NEW MEXICO.

By C. L. HERRICK, JOHN TERRY and H. N. HERRICK, JR.

The following notes are based on the collections of lizards made by the voluntary geological and natural history survey of the University of New Mexico during the season of 1898, with such additions as were possible from the collections made by the senior writer during several years previous. The area covered is chiefly within the Rio Grande valley between Albuquerque and Socorro and the area of the field-work in geology reported elsewhere in this volume. For specimens from Gallup we are indebted to Mr. Wallace Bowie, and for a few specimens from Magdalena to Mr. James Fitch. The object in presenting these fragments is simply to facilitate the prosecution of this work during the coming seasons and to give to the residents of the territory who may be willing to assist in it the basis for the recognition of the commoner species. None of our lizards are venomous and they are mostly to be ranked with the harmless, if not actively helpful, inhabitants of the plains and mountains. In many cases they are marvelously abundant, especially is this the case with the Holbrookias and smaller honed toads. The latter pass below ground in October and do not reappear till spring, while the smaller lizards may appear during the warmer parts of the day throughout most of the winter. They are, for the most part, subject to a great deal of individual and seasonal variation and many are provided with a remarkable degree of color adaptability in adjustment to the environment, so that, for example, species from the open sands are entirely different in markings and color scheme from those of more pro-

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tected stations. They also have the camelion-like power of adapting themselves in a short time to the color of the background.

LACERTILIA.

The lizards may be distinguished from the recent families of reptiles by their scaly bodies, the presence of limbs, the absence of a carapace, the three-chambered heart, the fact that the jaw is not dislocatable from its cranial attachment as in snakes or, more technically, by the following characters: quadrate bone articulated with the skull, parts of the ali- and orbitosphenoid regions fibro-cartilaginous, rami of the madible united by a suture, anal cleft transverse, copulatory organs paired.

KEY TO THE FAMILIES DESCRIBED.

I. Eyes with movable lids.
  a. Pupil elliptical, vertical; head without large plates, its skin freely movable, . . *Eublepharidae.*
  aa. Pupil round; top of head with immovable plates.
    b. A series of femoral pores.
      c. Lateral scales not abruptly smaller than the ventrals in numerous series; tongue not deeply divided, ... *Iguanidae.*
      cc. Lateral scales granular like the dorsals and smaller than the ventrals, which are in 8 longitudinal series, tongue ending in two slender points, ... *Teiidae.*
    bb. No femoral pores.
      d. Lateral scales very much smaller than the dorsal and ventral, usually hidden by a lateral fold; dorsal scales keeled, ... *Anguidae.*
      dd. Lateral scales not much smaller than dorsals and ventrals; no lateral fold; scales smooth.
        e. Scales on body flat, thin and imbricate, *Scincidae.*
        ee. Scales tuberculate, usually bony, with granular interspaces. Poison glands present, *Helodermidae.*
II. Eyes without lids; pupil elliptical, . *Xantusiidea,*

Family. EUBLEPHARIDAE.

This family is admittedly nearly related to the geckos, from which its members differ in the procœlian vertebrae and single parietal bone. The limbs are slender and the claws are retractile. The rather few species are widely distributed, the family being represented in North and Central America and in Asia. The color patterns among those widely separated species is very similar.

Coleonyx variegatus, Bd., has been found in Texas and in California and so may be expected to occur in southern New Mexico. It may be recognized by the characters of the family and the five dark brown bands crossing the yellow of the back. The eyelids have a series of pointed scales. Males have six to eight preanal pores.

Family. IGUANIDAE.

A very large family restricted to America and the islands of the Pacific with the exception of two genera from Madagascar. The species are diurnal, the eyes having round pupils and strongly developed lids. The teeth are sub-equal in size and usually conical. Femoral pores are usually present in the North American forms while often absent in those of South America. The form of the head shields is various and affords good generic and specific characters. In this paper the shield formed by the confluence of a number of plates about the parietal eye is called the interparietal and not occipital, as is done in many cases. The tympanum is distinct, except in Holbrookia. The species are generally insectivorous but many are partial to a varied diet and some seem to be strongly vegetarian. Phrynosoma and some species of Sceloporus are oviparous. From the excellent report of John Van Denburgh on the reptiles of California we take the following key to the genera likely to occur within our limits.

Synopsis of Genera of Iguanidae.

I. A low dorsal crest composed of one longitudinal series of enlarged scales, . . . *Dipsosaurus.*

II. No dorsal crest.

A. Head without spines.

a. One or more transverse gular folds.

b. Toes with a lateral fringe of movable spines, . *Uma.*

bb. Toes without spines.

c. Supralabial plates strongly imbricated; symphyseal plate smaller than the largest infralabial.

d. An ear opening, . . . *Callisaurus.*

dd. No ear opening, . . . *Holbrookia.*

cc. Supralabials not imbricated; symphyseal not smaller than the largest infralabial.

e. No large interparietal plate; caudal scales small, not strongly keeled or pointed.

f. Ear without strong denticulations and neck without spinose tubercles; supercilaries imbricate; tail long and tapering, . . *Crotophytus.*

ff. Ear with strong denticulations and neck with numerous spinose tubercles on lateral folds; supercilaries not imbricate; tail scarcely longer than distance from snout to vent, . *Sauromalus.*

ee. A very large interparietal plate; caudal scales large, strongly keeled, and sharply pointed, *Uta.*

aa. No complete transverse gular fold, . *Sceloporus.*

AA. Head with large spines posteriorly, . *Phrynosoma.*

Genus. DIPSOSAURUS.

The single species of this genus, Dipsosaurus dorsalis, Bd. and Gd., has been found in the Colorado and Mojave Deserts and is abundant in the neighborhood of Yuma. It probably does not occur within our limits. It is entirely vegetarian in habit.

Genus. UMA.

The two known species of Uma are not known to occur in our region, they being, like the last and the following, desert loving animals.

Genus. CALLISAURUS.

Callisaurus ventralis, the only species, within the United

States, was said to occur in Texas as well as in the desert region of southern California and Arizona. It may therefore occur in New Mexico. Stejniger, however, denies that it occurs in either Texas or New Mexico.

Genus. HOLBROOKIA.

Unlike the related genera, this genus is devoid of external ear discs, the tympanum being covered. The dorsal scales small, uniform; head scales small, interparietal enlarged. A long series of femoral pores; two transverse gular folds, the posterior with a denticulated edge; no abdominal ribs; males with enlarged postanal plates. The genus is limited to the southwestern part of North America.

Holbrookia Maculata, Girard.

Plate XIV, Fig. 1.

Holbrookia maculata, *Girard,* Proc. Am. Assoc. Ad. Sci., 1851; Stanbury's Expedition Gt. Salt Lake; *Cope,* Proc. U. S. Natl. Mus. 1880.

var. flavilenta, *Cope,* Proc. Acad. Nat. Sci. Phil., 1883; *Stejniger,* N. A. Flora, No. 3; *Boulenger,* Cat. Liz. Btit. Mus.

approximans, *Baird,* Proc. Acad. Nat. Sci. Phila.

maculata approximans, *Van Denburgh,* Cal. Acad. Sci., V, 1897.

Description: Body depressed fusiform, head short, V-shaped in perpendicular section; nostrils on the upper surface; head plates mostly small and irregular, except the interparietal, which is large, as wide as long; one or more series of axial scales in front of the interparietal larger than the other head plates; supraocular regions covered with small granules; superciliaries strongly imbricated; middle subocular plate very large; eyelids well fringed; about six upper labials, strongly imbricated; lower labials smaller, not imbricate, separated from enlarged sublabials by a row of small scales; gulars flat, not imbricate, but becoming so on the last gular fold; ventral scales larger than the dorsals and laterals, which are granular; a lateral fold between the fore and hind limbs which are short;

femoral pores about 12; tail short, abruptly narrowed at about the proximal third.

Color: Upper parts gray yellow or light brown, with two or four longitudinal series of dark splotches and numerous lighter spots; top of head like back but without definite pattern; upper surfaces of legs marbled with brown; throat white or yellowish, sometimes marbled with darker; tail with a single series of spots; under parts white or yellowish, with two or three transverse of black laterally behind the fore legs and which do not extend dorsally above the lateral fold and are sometimes edged with blue.

This little species is abundant everywhere in the Rio Grande valley and elsewhere in central New Mexico. It is extremely variable in color and adapts itself both temporarily and permanently to local color conditions. It feeds largely on plants and climbs readily.

Holbrookia Texana, (Troschel), Baird and Girard.

Plate XIV, Figs. 2-5.

Cophosaurus texanus, *Troschel*, Arch. f. Natur., 1850; Holbrookia texana, *Bd.* and *Gd.* Proc. Acad. Phila., 1852; U. S. Bound. Surv.; *Bocourt*, Miss. Sc. Mex. Rep.; *Cope*, Bul. U. S. Natl. Mus., 1880; *Boulenger*, Cat. Liz. Brit. Mus.

affinis, *Baird* and *Girard*, Proc. Ac. Phil., 1852.

Description: Body slender, head as long or longer than head and body; head very small, V-shaped in vertical outline; nasal openings dorsal, prominent; head plates mostly small and irrelegular except the interparietal which is not large, and a series of rather large axial plates in front of the latter; superciliaries large and strongly imbricated; one of the suboculars very large; eyelids fringed; about seven large imbricated upper labials; lower labials smaller, not imbricated, bordered below by one or more series of enlarged sublabials; gular scales flat, not imbricated; posterior margin of the gular fold feebly denticulate; ventral scales larger than the dorsals and laterals; a lateral fold extending from the fore to the hind limb; femoral pores from twelve to fourteen; males with enlarged postanal plates; tail slender; hind foot very long.

Color: background above pale gray to yellow; upper surface of tail and caudal half of the back marked with transverse bands of brown; anterior part of back with circular spots especially laterally: sides in front of hind leg marked with two deep black crescentic lines extending from the lateral fold toward the median line on a bright yellow field; upper surfaces of limbs with irregular dark markings; under parts white or yellowish; under surface of tail with transverse bars of black; throat and lateral belly patches blue in the male; a dark streak along the caudal aspect of thighs.

This beautiful species has been collected no further north than Socorro where it is not rare. It ranges from northern Mexico into the adjacent states.

Genus. SCELOPORUS.

Head and body somewhat depressed, shorter than the tail; no dorsal crest; dorsal scales keeled imbricate, equal; head scales large, especially the interparietal, usually with a definite pattern; no gular fold; tympanum distinct protected by strong teeth; femoral pores present; superciliaries imbricate.

Sceloporus Poinsettii, Baird and Girard.

Plate XV, Figs. 6-8.

Seloporus poinsettiii, *Bd.* and *Gd.*, Proc. Acad. Phila., 1852; U. S. Bound. Surv.; Sceloporus torquatus, var. C. *Bocourt*; toquatus poinsettii, *Cope*; torquatus cyanogenys, *Cope*; torquatus, var. poinsettii, *Boulenger*, Cat. Liz. Brit. Mus.

Description: Head and body somewhat depressed, very broad; nasal opening near the end of the snout, on the dorsal surface and within the canthus nasalis; upper head plates smooth, convex, not imbricated, irregular; interparietal largest; frontal divided transversely, caudal portion divided into four or more unequal parts, cephalic portion divided longitudinally; supra-oculars forming two irregular longitudinal rows, seperated from the axial head plates by a continuous series of smaller scales; superciliaries large, strongly imbricated, keeled, separated from the supra-occular by an irregular series of granules and small scales, middle sub-occulars as long as the remainder of the series, keeled; rostral plate narrow, nearly rectangular; labials low, upper and lower subequal; symphyseal plate large, pentagonal, followed by a series of plates larger than the gulars, not separated from the lower labials, the latter, however, in a double row; gular scales smooth, flat, bicuspid, strongly imbricated; those of a median portion of the belly not toothed, toward the sides first becoming bicuspid, then strongly denticulate; passing gradually into the dorsals; ear opening large, nearly vertical, protected by a small series of acuminate scales, only two of which are specially modified; scales of back broad, equal, slightly keeled, short-pointed and serrate, in longitudinal series but converging backward toward the median line; dorsals of the lumbar region, smaller than the caudal scales; scales of the sides pointing obliquely upward; no longitudinal dermal folds; a transverse gular fold behind the ear opening; upper surfaces of limbs covered with strongly keeled and long-pointed scales; scales on the posterior surfaces of thigh similar; upper caudal scales not serrate, strongly spined, spines directed obliquely outward; femoral pores varying from eleven to thirteen or more; six to ten dorsal scales equal in length to shielded part of head; number of scales from the interparietal to a line drawn through the posterior surface of thighs about 30; males with enlarged post-anal plates; tail as long as head and body.

Color: upper parts olivaceous brown, head darker; black collar in front of shoulders; distinct, nearly complete rings of dark on tail; back with dark, broad, irregular inconspicuous bands; male much darker than female; under side of throat bluish grey, in the male darker and more highly colored; bluish longitudinal bands on either side of abdomen in both sexes, merging into a dark spot in front of the thighs; under parts yellowish white; spines of upper surfaces of limbs dark-tipped.

Measurements: Total length, 215 mm.; Length to anus, 105 mm.; Length of tail, 110 mm.; Snout to ear, 26 mm.; Width of head, 27 mm.; Fore leg, 42 mm.; Hind leg, 70 mm.; Base of fifth to end of fourth toe, 20 mm.

This species has been found living upon rocks at an elevation of about 6,500 feet in the western part of the Magdelena mountains and is reported also from Socorro though no specimens are available from that place. Our specimens were kindly secured for us by Mr. James Fitch, of Magdalena. This species seems to be shy and restricted to rocky places in our range.

Sceloporus Magister, Hallowell.

Plate XVI, Figs. 9–11.

Description: Head and body little depressed, sub-cylindrical; nasal opening nearer the end of the snout than the orbit; upper head plates smooth, often somewhat convex, usually slightly imbricated; interparietal largest; frontal divided transversely, two portions sub-equal or caudal part larger; parietals and fronto-parietals not separated from the enlarged supraoculars; latter very broad as are the strongly imbricated superciliaries: middle sub-occular long, narrow and strongly keeled; rostral plate wider than high; labials long but very low, inferior longer than superior; symphyseal plate large, followed by several plates larger than the gulars, separated from the lower labials by one to three rows of narrow sub-labials; gular scales smooth, flat, bi-cuspid, strongly imbricated, as are those of the belly; ear opening large and nearly vertical, protected by a series of very long accuminate scales, four of which are specially modified and not keeled projecting backward and slightly downward; back with equal, keeled, strongly pointed scales bearing a spine on either side of the point, arranged in nearly parallel longitudinal rows; 14 rows of keeled dorsals; scales of sides ranging obliquely upward, merging gradually into the smooth ventrals. No longitudinal dermal folds; upper surface of the limbs provided with strongly keeled and pointed scales; scales on the poster surface of thighs large, accuminate, strongly keeled, and long pointed; upper caudal scales similar to the dorsals but longer pointed; femoral pores varying from 11 to 15 on each side; five to ten dorsal scales equal in length to the shielded part of the head; number of scales from interparietal to line connecting posterior surfaces of the thighs varying from 29 to 35; males with enlarged post-anal scales.

Color: back grey, yellow or brown, with indistinct mottlings of brown anteriorly; a black bar or collar in front of each shoulder; head nearly uniform; faint brownish rings on the tail; central patch of blue on throat of adult males; lateral band of blue bordered with black; a dark area in front of thighs; under parts white or yellowish.

Measurements: Total length, 194 mm.; Length to anus, 85 mm.; Lengh of tail, 109 mm.; Snout to ear, 20 mm.; Width of head, 18 mm.; Fore leg, 39 mm.; Hind leg, 54 mm.; Base of fifth to end of fourth toe, 23 mm.

Scelopus Clarkii, Baird and Girard, Proc. Acad. Nat. Sci. Phil. 1852.

Baird, U. S. and Mex. Boundary Surv., 1859; *Cope*, Proc. Acad. Nat. Sci. Phil., 1866; *Cope*, Check List, 1875. *Coues*, Synopsis of the Reptiles of Arizona, 1875. (Fig.) *Yarrow*, Check List of N. Am. Reptilia, 1882. *Stejniger*, N. Am. Fauna, No. 7. *Van Denburg*, Cal. Acad. Sci., V.

The relation between this species and Sceloporus magister, which is confessedly very close, has been discussed *in extenso*, in N. Am. Fauna, No. 7, by Stejniger, who claims that the two species are constantly distinguished by a difference in the spines guarding the ear openings; these modified spines being smaller and less acute in S. clarkii. There is said to be a difference in habit also and although the habitats overlap in south-eastern Arizona, the stations affected by the two species are said to be different, S. magister affecting an arboreal life while S. clarkii is found upon the rocks. It is probably that this species will be found in the extreme south-western part of the territory.

The species extends into Mexico an unknown distance. Farther south, it is said to be replaced by S. boulengeri, which is similar to S. clarkii but has fewer femoral pores, short and broad ear spines and a very broad interparietal. S. acanthinus is said to be modification of the same type still further to the south.

Sceloporus Occidentalis, Baird and Girard. (?)

Plate XVII, Figs. 12–14.

Description: Head and body somewhat depressed; nasal openings nearer the end of snout than the orbit; upper head plates smooth, somewhat convex, somewhat imbricated; interparietal largest; frontal divided transversely, cephalic portion larger; parietals and frontoparietals separated from the enlarged supraoculars by a series of granules; latter in the single series, very broad and convex, separated from the narrow, imbricated superciliaries by a series of granules, middle suboccular long and keeled; rostral plate broader than high; labials long and low, the upper and lower nearly equal; symphyseal plate very large, followed by a row of enlarged plates on either side, which are separated from the lower labial by a single row of sublabials; gular scales smooth, flat, some of them bicuspid; strongly imbricated; ear opening of moderate size, protected in front by about three enlarged scales; back with equal, keeled, short-pointed scales in longitudinal parallel rows; about 22 or 24 rows of keeled dorsals; scales of sides ranging obliquely upward, passing gradually into the smooth ventrals; scales of the dorsal surfaces of the limbs like those of the back, those of the posterior surfaces of the thighs smooth, no longitudinal dermal folds; scales of the tail like those of the back, but larger; femoral pores 16 to 18; about ten dorsal scales equal in length to the shielded part of the head; number of scales from the interparietal to a line connecting the posterior aspect of the thighs 40 to 42; males with enlarged postanal scales.

Color: Brownish or grayish above, with a lateral light stripe on either side, crossed a zig zag line of dark brown which usually does not cross the median line but may cross the light lateral bands and merges with the darker coloring of the sides; head marked with brown, especially a transverse line connecting the supercilaries and another in front of the eyes; a dark line passing through the eyes; upper surfaces of legs marbled with dark; tail obscurely ringed with dark; lower parts light; male with two spots on the gular region, not confluent on the median line; flanks blue, passing into black; black spot in front of shoulder.

Measurements: Length of anus, 57–55 mm.; Snout to ear, 15–13 mm.; Width of head, 12–11 mm.; Fore leg, 28–27 mm.; Hind leg, 34–32 mm.; Base of fifth to tip of fourth toe, 15–14 mm.

With the materials at hand it is impossible to discriminate S. occidentalis from S. biseriatus. The basis of separation offered by Van Denburgh in the coloration of throat, which in males of S. occidentalis said to have two dark lateral spots, while in S. biseriatus they may be confluent. He says "I have examined many hundreds of specimens of S. occidentalis and biseriatus and have not found a single male of the latter with two blue throat patches. Highly colored male of S. occidentalis are sometimes found in which the two blue patches have extended to end even merged on the median line, but by securing very young or less brilliantly colored males, there should be no difficulty in determining which species occurs in a given locality." Unfortunately he omits to say how he knew that he was dealing with a given species while determining the validity of the sole criterion. S. occidentalis is said to be the more northern species. It may be that the best plan is to accept Boulenger's suggestion and call all the phases of this exceedingly variable group varieties of S. undulatus. This form, whatever it is, is extremely abundant in the Rio Grande valley and the range of individual variation is enormous.

Sceloporus Consobrinus, Baird and Girard.

Description: Head and body little depressed, fusiform; nasal opening nearer the end of the snout than the orbit; upper head plates smooth, somewhat convex, not obviously imbricated; interparietal largest; frontal divided transversely, cephalic portion much larger than the caudal; parietals and frontoparietals separated by small granules from the enlarged supraoculars; latter broad (but not so broad as in S. magister) and separated by a number of scales from the narrow, imbricated superciliaries; sub-occular keeled; rostral plate wider than high;

internasals large labials long but narrow, the inferior larger than the superior; symphyseal plate larger than the rostral, followed by several plates larger than the gulars, separated by one row (or two incomplete rows) of sub-labials from the lower labials; gular region with scales smooth, flat, bicuspid, and strongly imbricated like those of the belly; ear opening large and nearly vertical, protected by three or four small, acute, modified scales; back with moderate-sized, keeled, simply-pointed scales in parallel rows; scales of sides ranging obliquely upward; about 45 scales in a dorsal series from cephalic plates to a line drawn through the posterior border of the thighs; transition from the lateral to ventral scales gradual; no longitudinal dermal folds; upper surfaces of the limbs with keeled and pointed scales, like those of the back; scales of the posterior surfaces of the thighs not enlarged; upper caudal scales similar to the dorsals; about 14 femoral pores; about 8 to 12 dorsal scales equal in length to the shielded part of the head.

Color: pale olivaceous brown; head darker and uniform; back with narrow whitish bands one on either side and separated by a broad area in which is a double row of dark, irregular blotches which may be edged with lighter; sides passing gradually into the white of the lower aspects; a dark line from the posterior canthus of the eye to upper angle of ear opening and thence bordering the lateral light line laterally to the tail; upper and lower labials darker than adjacent parts; limbs marbled with dark brown; tail with obscure dark rings. (The above description refers to the female, the male being more highly colored.)

Measurements: Total length, 145 mm.; Length to anus, 71 mm.; Length of tail, 74 mm.; Snout to ear, 15 mm.; Width of head, 14 mm.; Fore leg, 27 mm.; Hind leg, 41 mm.; Base of fifth to end of fourth toe, 18 mm.

This species seems not to be uncommon in the Rio Grande valley near Socorro. Collected by John Terry and Harry N. Herrick.

Sceloporus Gratiosus, Baird and Girard.

Description: Head and body somewhat depressed; nostrils opening much nearer to the end of the snout than to the orbits; uppear head shields smooth, moderately large, and slightly convex, interparietal largest; frontal usually divided transversely; parietal, frontoparietal and frontal plates separated from the supra-occulars by a series of small plates of granules; superciliaries long, wide, and strongly imbricated; middle sub-occular very long, narow strongly keeled; rostral plate very wide and rather high; labials long, low, and almost rectangular; below lower labials series of large sublabial plates; symphyseal arge, pentagonal; gulars small, smooth, imbricate, frequently emarginate posteriorly, about the size of the ventrals; ear opening large, slightly oblique, with an anterior armature of from four to seven accuminate scales; dorsal scales equal, keeled, pointed, and arranged in longitudinal parallel rows; scales on sides similar to those of the back, but directed obliquely upward; no longitudinal dermal folds; superior surfaces of the limbs with keeled scales; posterior surfaces of thighs with small smooth scales; ventrals smooth but usually bicuspid; caudal scales very much larger than the dorsals, heeled and strongly pointed; femoral pores varying in number from twelve to twenty; eleven to seventeen dorsal scales equal in number to the shielded portion of the head; scales in the longitudinal row from parietal plate to a line connecting the posterior aspects of the thighs varying from 45 to 66; males with enlarged postanal plates.

Color: above, brown, olive or bluish or greenish gray; with one dorsal and two lateral series of closely set brown spots on each side, spots sometimes more or less confluent, forming longitudinal bands separated by narrower bands of the lighter ground color; tail usually with trace of darks rings; males with a blue spot, sometimes bordered with black, on each side of the belly; throat more or less washed with blue which has a tendency to form narrow oblique lines.

This species is closely related to S. consobrinus, but is smaller. It occurs in the mountains of California, Utah and

Nevada and will doubtless be encountered in the northwestern parts of New Mexico.

After careful comparison of descriptions by various authors we incline to believe that this but a smaller mountain-loving race of S. consobrinus. One of our specimens of the latter species is but 130 mm. but otherwise resembles the types.

Genus. PHRYNOSOMA.

The horned toads are among the most characteristic of lizards and form a rather compact American group which are not to be confused with any other. Their bizaire spiny, disc-like bodies and short horned heads which they know well how to use in the defensive and even in offensive struggles are eminently characteristic. The plates of the head and body are heterogeneous and tend to assume the spinous form while the existence of strong bony spines from the back of the head is a universal character. The tympanum is distinct and may or may not be covered with scales. There is a transverse gular fold and usually a series of peripheral spines along the lateral margins of the body. Femoral pores are present. The tail is short as are the legs. The digits have keeled lamellae below. Lateral teeth subcoincal or indistinctly tricuspid ; no pterygoid teeth. No abdominal ribs. A large sternal fontanelle. Other osteological characters may be gathered from the figures.

In our region (eastern New Mexico) we have been able to distinguish but three species though there is a considerable range of variation which may serve to invalidate some so-called species. These animals are essentially insectivorous and sluggish and rely upon their spinous armature for protection as well as upon their very considerable power of modifying the color of the skin to conform to the color of the station. This power is due to the capacity of the chromatophores to alter their form in obedience to nervous stimuli of varying kinds.

They protect themselves from the extremes of heat and cold by burying themselves in the earth. We have never been able to observe that they construct burrows but they sink into the sand in such a way as to completely cover the body and may be seen after a cold night imerging from the sauce-like depression so made.

Like many others we long regarded the statement that these animals sometimes discharge a qauntity of blood from their eyes when disturbed as a fable. Upon a single occasion however we have had an opportunity to verify this statement. So far as we could discover the animal was not injured and we have handled others much more roughly without such a result but in this case (P. cornutum) a large drop of a red fluid was thrown out from the eye and moistened its head as well as the hands of the intruder.

Although the most peaceful of animals, the horned toads defend themselves with energy. The writer once witnessed a contest between two large lizards (Crotophytus) and a very large specimen of P. douglassii. The toad threw himself into the most amusing posture of defense by kneeling down with the legs of one side while standing on tip toe with the opposite set and thus presenting the shield-like dorsal surface to the enemy. With a single opponent these tactics succeded well and the lizard received some shrewed thrusts with the powerful horns, but when there were two foes it was easy for one to take advantage of the weaker side and sieze the toad in the soft region under the neck where he hung with a grip not to be shaken off.

KEY TO THE GENUS PHRYNOSOMA.

The following key is largely a compilation from various sources and we suspect that there may be synonyms or at most geographical races among the species enumerated. It is hoped that the table such as it is may nevertheless be serviceable.

A. Nostrils opening on or near the lines connecting the supraorbital ridges with the end of the snout (canthi rostrales).

  a. Gular scales small, nearly equal in size; a series of enlarged scales below, but not larger than, the lower labials.

    b. Head spines short (variable); occipitals shorter than the transverse diameter of the eye ball. *P. douglassii.*

bb. Head spines moderately large, occipitals as long as the transverse diameter of the eye; gular scales perfectly smooth, . . *P. orbiculare.*

aa. Several longitudinal series of enlarged pointed gular scales; a series of large spinose plates below the lower labials; head spines long.

b. Gular scales spinose.

c. Head shields convex and almost smooth. *P. blainvillii.*

cc. Head shields flat, with numerous ridges and granulations, ... *P. frontale.*

bb. Gular scales feebly keeled.

c. Occipital spines extend upward and outward. . . . *P. boucardii.*

AA. Nostrils opening in the line of the canthi rostrale or slightly above; several longitudinal series of enlarged gular scales; a series of very large bony shields below the lower labials.

a. Occipital spines directed obliquely upward, like the temporals; ventral scales smooth, . *P. coronatum.*

aa. Occipital spines vertical, erect; ventral scales keeled. . . . . . . *P. asio.*

AAA. Nostrils pierced within the canthi rostrale; gular scales small, equal or with one series of enlarged ones on either side.

a. Tail longer than the head.

b. Head bordered posteriorly by a series of contiguous large spines, of which four are occipital. *P. regale.*

bb. Two occipital spines larger than the other head spines, with an interval between their bases and those of the temporal.

c. Enlarged dorsal tubercles spinose, erect; tympanum naked, ... *P. cornutum.*

cc. Enlarged dorsal tubercles flat, or feebly raised; tympanum covered with scales; occipital spines as long as the horizontal diameter of the orbit; two or three series of peripheral spines; 18–20 femoral pores, . . . *P. platyrhynus.*

ccc. Enlarged dorsal tubercles flat or feebly raised; tympanum covered with scales; occipital spines shorter than the transverse diameter of the eye; peripheral spines a single series or nearly absent; 6–12 femoral pores; more than three sublabials enlarged,. . . . *P. platyrhynus.*

cccc. One series of peripheral spines; 7–10 femoral pores; only three sublabials enlarged. . . . . . *P. goodei.*

bbb. Two occipital spines not longer than the longest temporals, ... *P. modestum.*

c. Tail not longer than head.

d. Occipital spines a little larger than the temporals. . . . *P. braconnieri.*

dd. Occipital spines much smaller than the temporals. . . . . . *P. taurus.*

The following probable synonyms are indicated: P. planiceps is a variety of P. cornatum., P. brevirostris is P. douglassii., P. ornatissimum is P. douglassii., P. solaris is P. regale.

Sp. 1. *Phrynosoma Douglassii*, Bell.

Plate XVIII, Fig. 15.

This is the common species in she mountains and upland mesas in northern New Mexico.

Description: Nostril opening on the canthi rostrales; gular scales small, near equal in size; a series of enlarged sublabial scales which are not much larger than the infralabials and are separated by several rows of granules. Infralabials (in a large specimen) 16 on a side, increasing toward the angle of the mouth and there ending in a large spine; sublabials 9 on a side; supralabials not enlarged and passing laterally into small granular scales; head spines rather small, about equalling the transverse diameter of the orbit; four temporals, one occipital and one postorbital spine on a side; other head scales small and irregular, roughened with ridges and granulations; one or two gular folds; tympanum not covered with scales; back covered with sharp, keeled, tubercular spines, which are irregularly distributed; a single row of sharp spines along the sides; tail with a lateral and two dorsal rows of spines; scales on the breast, belly and proximal aspect of the tail smooth, but those on the terminal part of tail keeled; in a large specimen the latter bands, as well as the blotches of dark on the back often indistinct; lower surfaces pure white.

Measurements: Length of anus, 40 mm.; tail, 20 mm.; snout to eye, 10 mm.; width of head, 16 mm.; length of occipital spine, 3 mm.; fore leg, 25 mm.; hind leg, 35 mm.; base of fifth to end of fourth toe, 10 mm.

Sp. 2. *Phrynosoma Cornutum,* (Harlan) Gray.

Plate XIX, Fig. 16.

This seems to be the commoner form in the valley of the Rio Grande.

Description: Head as broad or broader than long; nostrils opening the canthi rostrales; tympanum naked; gules scales keeled, with a longitudinal series of enlarged pointed scales on either side of neck; gular folds several, irregular, a series of very large projecting sublabial scales; infralabials head spines large, the occipital being much larger than the three temporals and directed obliquely upward and outward; interoccipital and postorbital present.

Back with very large erect spinose tubercles, the longest of which form a series of three or four on either side the vertebral line; two lateral series of spines of which the upper are longest; pectoral and ventral scales more or less distinctly keeled; femoral pores twelve on a side not extending upon the preanal region; no enlarged postanal scales. The body is one and a half times as long as the tail. Scales of head pustulose or longitudinally striate, spines ribbed.

Dorsal surface of head isabelline brown, mottled with white with two black cross bands between the canthi rostrales, a band from the eye to the angle of mouth, another black band from eye to temporals, about the mouth and cheeks ochraceous brown; under parts of head mottled with black as also the lateral margins of body below; dorsal surface with 4 longitudinal rows of dark spots edged with lemon yellow, bright yellow patch on shoulder; narrow white median dorsal line; 66 rows of scales on belly; long series of femoral pores nearly meeting in front of anus; two groups of slender spines behind the tympanum.

There are four rows of black spots on the back; each spot bordered by strips of white and yellow; space between the spots ocheraceous; tail with six double rows of black spots; underneath white often mottled with numerous black splotches.

Measurements of large individuals.

Length to anus,	100 mm.	80 mm.	42–100 mm.
Length of tail,	31 "	30 "	17– 40 "
Snout to ear,	28 "	20 "	10– 21 "
Width of head,	30 "	24 "	12– 27 "
Length of occipital spine,	4 "	2 "	1– 2 "
Length of fore leg,	42.5 "	32 "	18– 35 "
Length of hind leg,	56 "	43 "	23– 45 "
Base of fifth to end of fourth toe,	14 "	12 "	7– 15 "

Coloration of specimen from San Pedro mountain at 7000 feet. Upper surface of head mottled with brown and white; six pairs of vandyke to umber brown blotches on neck and body, the two middle pairs double as by confluence of two, spots bordered behind by a dark band shading into brown, this still bounded posteriorly by a narrow band of brilliant orange; intervals between spots irregularly shaded with orange, yellow and brown; numerous white spots on the side; irregular gray bands on either side the median line; tail with seven dark bands, belly burnt sienna with numerous small dark spots, whitish on sides with brown bands and spots.

Sp. 3. *Phrynosoma Platyrhynus*, Girard.

Plate XX, Fig. 18.

This species is excessively abundant in the valley of the Rio Grande and elsewhere at lower levels in the eastern part of the territory. It is rarely seen of a large size and is greatly exposed to the attacks of its enemies though it possesses the power of changing color to a greater extent than the others.

Description: Nostrils opening above the canthi rostrales; gular scales small, granular; one gular fold; a series of large, spinose sublabial scales which increase posteriorly; infralabials not separated from sublabials (in small specimens at least) by a series of scales but the two series in juxtaposition; two groups of weak spines on either side of neck; head spines rather short, consisting of from five to seven temporals, one occipital and postorbital; three scales in front of the occipital larger than the remaining head scales which are roughened with granulations and ridges and, except those in front of the occipital and temporal spines nearly flat.

Back, tail and upper surfaces of the limbs covered with scattered, slightly elevated, keeled, tubercular scales; one series of peripheral scales which disappears behind or is obsolescent; tail edged with small spines; scales in front of arm large, pointed, strongly keeled; those on breast, abdomen and proximal part of tail smooth; tympanum covered with scales; femoral pores nine on a side, invading the preanal region; males with enlarged postanal plates.

General color above, gray, yellowish brown, etc., variously marbled with slaty, brown or blackish; a large dark area on either side of the neck often extending back to in front of hind legs, tail transversely banded.

Genus, UTA.

Head and body moderately depressed and shorter than the tail; tympanum distinct; no dorsal crest; dorsal scales small, keeled, either uniform or heterogeneous; head plates large, the interparietal being larger than the ear opening; one or more transverse gular folds, the anterior one with denticulated edge; labials not imbricated; superciliaries imbricated; femoral pores present; lateral teeth tricuspid; no pterygoid teeth; a large sternal fontanelle; no abdominal ribs; males with enlarged postanal plates. This is a genus confined to Mexico and the southwestern states of the Union.

KEY TO THE AMERICAN SPECIES.

I. Dorsal scales uniform, larger than those of the flanks.
  a. Dorsal scales not imbricate, smooth, a narrow black band from shoulder to shoulder above, . . . *U. mearnsi.*
  aa. Dorsals imbricate, keeled, no black band from shoulder to shoulder, a round blue spot behind the axilla, . . . *U. stanisburiana.*
II. A band of six or eight longitudinal series of equal enlarged scales along the middle of back.
  b. A lateral line of special scales, . *U. ornata.*
III. Dorsal scales heterogeneous.
  c. Slender, tail more than twice as long as head and body, enlarged dorsals sub-equal, *U. gratiosa.*
  cc. Stouter, tail less than twice as long as head and body, largest dorsals in four series, *U. symmetrica.*

Uta Ornata, Baird and Girard.

Uta ornata, *Bd.* and *Gd.*, Proc. Acad. Sci. Phila., 1852; U. S. Mex. Bound. Surv.; *Boulenger*, Cat. Liz. Brit. Mus.

"This species may be distinguished from U. stanisburiana, of which it has the general appearance, by a dorsal space covered with five or six rows of scales larger than those on the sides of the body. Along the middle of the sides there exists one row of small scutellae imitating the lateral lines of fishes. The ground color is reddish brown, with transversely elongated black patches all along the upper part of body and tail. The belly is unicolor in the female while it is blue in the male." The range is said to be from Texas to California. It has not been encountered by our collectors.

Uta Stanisburiana, Baird and Girard.

Plate XXI, Fig. 19.

Uta stanisburiana, *Bd.* and *Gd.* Proc. Acad. Nat. Sci., Phila., 1852; Stanisbury's Exp. Gt. Salt Lake, 1853; *Boulenger*, Cat. Lizards Brit. Mus.; *Van Denburgh*, Bul. Cal. Acad. Sci. V.

Uta elegans, *Yarrow*, Proc. U. S. Natl. Mus. 1882.

Description: Head and body depressed; head truncately pointed in front; head plates flat smooth; interparietal largest; frontal plate divided transversely, followed in a cephalic direction by an irregular series of enlarged plates; three to five supraoculars enlarged and separated from the frontals by small granules; superciliaries imbricate, few, projecting; central subocular large keeled; rostral and supralabials long and low; the other plates of the upper surface small or granular; symphyseal plate rather small, followed on either side by larger smooth plates which are separated from the infralabials by one to three series of sublabials; gular region covered with small, smooth, nonimbricating scales; gular fold with a series of projecting spines; tympanic opening with an armature of three enlarged spines; lateral dermal folds present; back with keeled scales hearly uniform in size but graduating into those of the side, on the neck and sides granular scales; scales of tail large, keeled and pointed; femoral pores from twelve to seventeen.

Color: Upper parts with a ground color of brownish or yellowish gray densely spotted with darker and lighter; a more or less distinct light band on either side of the back, most distinct anteriorly; the small spots ol the upper surface tend to be blue or green and often give to the animal a prevailing tone of that color; tail often with dark rings; upper surfaces of limbs spotted like the back; toes of hind feet with dark bands; under parts light, variously marbled with dark; throat blue with light spots; an irregular blue spot behind the fore leg which is surrounded by a light band; usually a brown spot in front of the shoulder; sides marked with large light spots.

This graceful species is abundant in the Rio Grande valley at Socorro and further north. It is active and restricted to the ground.

Genus. CROTOPHYTUS.

Head and body depressed or sub-cylindrical, much shorter than the very slender tail; no dorsal crest; a gular fold; tympanum present; all the head plates small; labials not imbricate; dorsal scales small and nearly uniform; a long series of femoral pores; males with enlarged preanal plates; lateral teeth tricuspid; pterygoid teeth; no sternal ribs; no sternal fontanelle. These large and very active lizards occur in the southwest states and northern Mexico. They are predaceous and even cannibal in their habits. Two species are known to occur in New Mexico.

Crotophytus Wislizenii, Baird and Girard.

Crotophytus wislizenii, *Bd.* and *Gd.* Proc. Acad. Sci., Phila., 1852; Stanisbury's Exp. Salt Lake, 1853; *Baird,* Mex. Bound. Surv. 1859; *Boulenger,* Cat. Liz. Brit. Mus.; *Van Denburgh,* Bul. Cal. Acad. Sci. V.

Crotophytus gambelii, *Baird* and *Girard, l. cit.*

Description: Body slender and strong; head large, depressed and broad behind; head plates small, larger toward the snout; snout convex; three to five longitudinal rows of shields between the supraocular regions; nostrils nearer the end of head than the orbit; superciliaries small, imbricate; a long subocular plate; rostral plate very low; supralabials of nearly equal size; lower labials somewhat larger than the upper, bordered below by several series of small plates larger than the gulars; symphyseal plate large; tympanic opening large oblique; one strong gular fold with sometimes two additional ones; back and sides covered with small granules merging into the larger scales of the belly; latter imbricate and sometimes keeled; irregular lateral dermal folds; tail cylindrico-conical, more than twice as long as the head and body; males with enlarged postanal plates.

Color: Upper parts browish gray, the head darker, with creamy white lines surrounding the orbits and in the supraocular regions and the snout; back crossed with alternating light lines; between each pair of which a round spot of brown; the proximal part of tail like the back, the distal part ringed with dark; upper surface of limbs marbled or spotted. With age the spots on the back break up, the bands disappear or become more marked and the whole color fades. No two specimens are exactly alike. There is a change during the breeding season, especially in the females.

This species seems to occupy the entire territory at suitable stations but does not ascend into the mountain canons, where its place is taken by C. Collaris. So far from being sluggish, we have found it the most active and wary of our lizards. It will fight viciously and devours other species of lizards and upon occasion, young of its own species.

Crotophytus Collaris, Say.

Plate XXII, Fig. 20. Plate XXIII, Fig. 21.

Agama collaris, *Say,* Long's Exped. Rocky Mts., Harlan. Med. Phys. Res.

Crotophytus collaris, *Holbrook,* N. A. Herpetology; *Wiedman,* Nova Acta, 1865; *Baird,* Pacific R. R. Surv. Pl. XXIV; *Cope,* Proc. Acad. Phila., 1866; *Boulenger,* Cat. Liz. Brit. Mus.

Description: Head large, depressed, much swollen posteriorly, especially in the males; body fusiform; tail long and terete; legs very long and strong; plates of head all small, two or more series between the granules of the supraocular regions; nostrils large and opening laterally; superciliaries small and imbricate; supralabials of about equal size; a large subocular plate; ear opening large, oblique, without prominent armature; symphyseal plate large, followed by two short rows of somewhat enlarged plates; one or two well-developed gular folds; back and sides covered with small granules; ventral region with larger scales; femoral pores from sixteen to twenty-two.

Color: Upper surfaces olive or browish gray, quite variable and variously spotted and barred with lighter color; two intensely black transverse shoulder bands which do not meet above, the anterior one being interrupted by a V-shaped sepia band on the nape; under parts white, the throat and sides mottled with darker; tail near the end with dark rings. The form living in the mountain canons seems to be darker than that occuring on the upland mesas and the spots are larger and interrupted by transverse bars. The following description of a living specimen illustrates a common type of coloration:

Head above light brownish gray irregularly bloched with sepia; about seven blotches of orange red back of ear; band of coral red in scapular region; first pair of scapular bands of black separated above by a V-shaped band of sepia; back sepia gray with small yellowish white spots; upper aspects of legs greenish; upper surfaces of hand and fingers yellow three or four spots of coral red on sides; hind legs of lighter color than back with numerous spots of sepia brown; sides of thighs yellowish green; tail ringed with alternate bands of slate color and sepia; under parts white with pale brown spots on under surface of head.

This species is not found in the immediate valley of the Rio Grande, or, if at all, very rarely, but is a resident of the lower parts of the mountain canons and the mesas adjoining. In habits it is similar to the preceding species. It is a beautiful and sprightly animal. How the C. baileyi, Stejniger is to be distinguished from this common form we are unable to say at this writing.

Family. ANGUIDAE.

Tongue composed of two distinct portions, a principal posterior part covered with villiform papillae, and a small anterior portion, which is thin, emarginate and retractile into the basal part. The body is protected by bony plates underlying the scales, the latter being imbricated and tuberculate. An occipital plate is present. The teeth are variable and bear some resemblance to those of the Gila monster. Skull with distinct nasals, single parietal. Abdominal ribs absent. Limbs sometimes rudimentary. This family is most abundantly represented in Central America and the West Indies but is represented by the slow worm of Europe and by a few closely allied species in North America.

Genus. GERRHONOTUS.

Limbs well-developed, pentadactyl; lateral fold present; scales squarish or rhomboidal, forming transverse series; eye large with a round pupil; no femoral pores or enlarged postanal plates; ear opening distinct; no gular fold. A group of closely allied species of this genus occupies the entire western coast of North America, G. Cœruleus (G. scincicaudata) being the type.

Boulenger says this species extends as far east as Texas and also describes G. kingii from Deming in southern New Mexico. The latter is regarded by Dr. Gunther as a variety of G. cœruleus. The following description is taken from Van Denburgh in part.

Gerrhonotus Scincicaudata, Skilton.

Description: Body long and rather slender, with short limbs and very long tail; head pointed, with flattened top and nearly vertical side, temporal region often swollen in old specimens; rostral plate rounded in upper outline, preceded by a pair of small internasals, a pair of small frontonasals, very large azygous prefrontal, a pair of large prefrontals, a long frontal, a pair of frontoparietals, two parietals separated by an interparietal, a pair of occipitals, and (usually) a single interoccipital; two series (of 5 and 3) supraocculars and a series of small superciliaries. Upper labials much rargc than lower, below the latter two series of large sublabial plates, lower larger; gular scales smooth and imbricate; scales on the upper surfaces large rhomboidal, strongly keeled, arranged in longitudinal and transverse series; about 14 longitudinal series of dorsals and number of transverse series to back of thighs from forty-one to fifty-two. A band of granules under the lateral folds; ventral plates about the size of dorsals, imbricate, smooth, the grayish or brownish color of the back crossed by from nine to sixteen continuous irregular dark bands; lower parts white or yellowish with brownish or grayish suffusions.

G. knightii is said to differ in having only six or eight of the dorsal series of scales keeled. It will require further study to determine the value of this distinction.

(Family. ANNIELLIDAE.)

The student should be alert for the discovery of subterranean species of this family which, so far as now known, is confined to California. The body is cylindrical and snake-like and the external limbs are absent.

Family. HELODERMATIDAE.

The Gila monsters are the only lizards with venom-secreting glands but they are fortunately so sluggish as to rarely strike even when disturbed. They may be recognized by their large size, tubercular skin and snake-like dentition.

Genus. HELODERMA.

Characters of the family.

Heloderma Suspectum, Cope.

Description: Large, heavily set, clumsy in form, with short legs and tail; nostrils large, opening laterally between three plates; eye small; ear opening large oblique; rostral and symphyseal plates large; a pair of internasals; three pairs of plates behind the symphyseal; gular region with the small tubercles passing into the plates of the belly; upper parts covered with smooth convex tubercles, separated by granules, lateral tubercles passing into the squarish plates of the belly; a pair of enlarged preanal plates.

Color: Upper parts variously and irregularly marked with dark brown and salmon color; tail sometimes ringed; belly orange or salmon, with tessalted markings of brown.

The Gila monster probably occurs in this territory only in the southwestern portion.

Family. TEIIDAE.

New world lizards related to the true lizards of Europe (Lacertidae). Head shields free from the cranial ossifications; nasals double, frontal are parietal single; tongue slender and ending in two smooth points; head covered with large, regular plates; ear opening and eyelids usually present; femoral pores may be present. A very large family represented within our limits by a single genus.

Genus. CNEMIDOPHORUS.

Four pentadactyl limbs; head plates large; two frontoparietal plates; back and sides covered with small uniform granules; ventral plates large and serially arranged; eye lids and ear openings present, pupil round; two or more gular folds; femoral pores numerous.

Cnemidophorus Sexilieatus, Gray.

Plate XXIV, Figs. 23, 24.

Description: Slender, agile; head nearly flat above, with nearly vertical sides; snout slender; rostral plate large, high, triangular; nostrils opening within the large nasal plates which are partly enveleped by the rostral; posterior nasal nearly quadrangular, articulating with the anterior nasal, first, second, and third labials, loreal, frontal, and prefrontal plates; four enlarged supraoculars, the two in the middle largest, all of them separated from the superciliaries by a row of granules; superciliaries not imbricated, the anterior two large; supraoculars separated from parietals and frontoparietals by granules; occipitals in two or more irregular transverse bands; about five superior and six inferior labials to middle of eye; inferior labials larger than the upper; sublabials very large, connected with the symphyseal by a large azygous plate, separated from the lower labials by three or four large plates and a short series of granules in front of them; intermandibular region of throat with larger scales than the throat behind the ears to the first gular fold, behind the latter larger scales merging into those of the throat; ventral scales large, in eight longitudinal rows; upper surface with small equal granules; ear opening large, semicircular; external aspect of upper arm and cephalic aspect of fore arm with enlarged scutes; *ventral aspect of fore arm with a patch of enlarged scales below the elbow;* scales of ventral aspect of hind legs very large; *femoral pores from 16 to 18;* scales of tail strongly keeled; about three enlarged preanal scales.

Color: Above dark olive brown, passing into clear olive on the head and greenish olive on the tail; back marked with three narrow, distinct yellowish white lines on either side and sometimes a faint median stripe on the median line, the latter more distinct anteriorly; upper surfaces of limbs faintly marbled; sides of head and under parts immaculate.

Only a few specimens of this species, which is referred to

C. sexlineatus only doubtfully have been found among the numerous individuals of the next and nothing can be said of its range or habits. It is true that it seems to vary in the direction of C. undulatus but the forms seen are easily distinguished from that species.

Cnemidophorus Undulatus, Hallowell.

Plate XXIV, Fig. 22.

This is perhaps the commonest lizard in the Rio Grande valley and is everywhere in evidence. It differs from the preceding species in the absence of the patch of enlarged scales on the under aspect of the fore arm and in the colors. The back is marked by from seven to nine wavy dark bands which, in the older individuals, break up into irregular blotches to the almost entire suppression of the longitudinal arrangement; the sides of the head are distinctly marked with dark spots but the spots on the throat are small and scattering; head and tail olive. We have not seen typical specimens of C. tigris but they no doubt occur and will be recognized by the almost entire absence of the black markings on the sides of the head and a suffusion of gray on the throat. The color of the back is more minutely broken up.

Family. SCINCIDAE.

Tongue slightly notched at the tip; head covered with large regular plate scales on body and tail of moderate size, imbricate, supported by bony plates; eyelids present; pupils round; dendition pleurodont; no femoral pores.

Genus. EUMECES.

All the scales are thin, smooth and imbricate. There is a distinct ear opening and the gular and lateral folds are absent, limbs pentadactyl; nostril penetrating the nasal plate; digits not denticulated laterally. The skinks are of world-wide distribution and three species at least have been reported from New Mexico but as we have but once encountered a representative and have no authentic material it seems best to reserve the mention of these till material shall have been collected. It is to be sought in moist places as under stones near springs and in deep woods.

DEFINITION OF TERMS.

Azygous.—Not paired.

Canthus rostralis.—The ridge from above the eyes to the extremity of the snout.

Femoral pores.—Gland openings along the lower surface of the thighs.

Frontal plates.—One or more plates on top of the head between the supra oculars.

Frontoparietals.—Plates on top of head between the parietals and the frontal.

Gular fold.—Fold of skin crossing the throat.

Gular scales.—The scales of throat.

Infralabials.—Scales of lower lip.

Internasals.—Plates of snout behind the rostral.

Interparietals.—The plate on top of head in which is the pineal or parietal eye.

Labials.—Scales of the edge of lip.

Occipitals.—Plates behind the parietals and interparietal.

Parietals.—Plates on either side of the interparietal.

Rostral.—Plate on end of snout.

Sublabials.—Plates below the lower labials.

Superciliary.—Plates on upper aspect of orbit of eye.

Supraocular.—Scales over the eye mesally of the superciliaries.

Symphyseal.—Scale at tip of lower jaw.

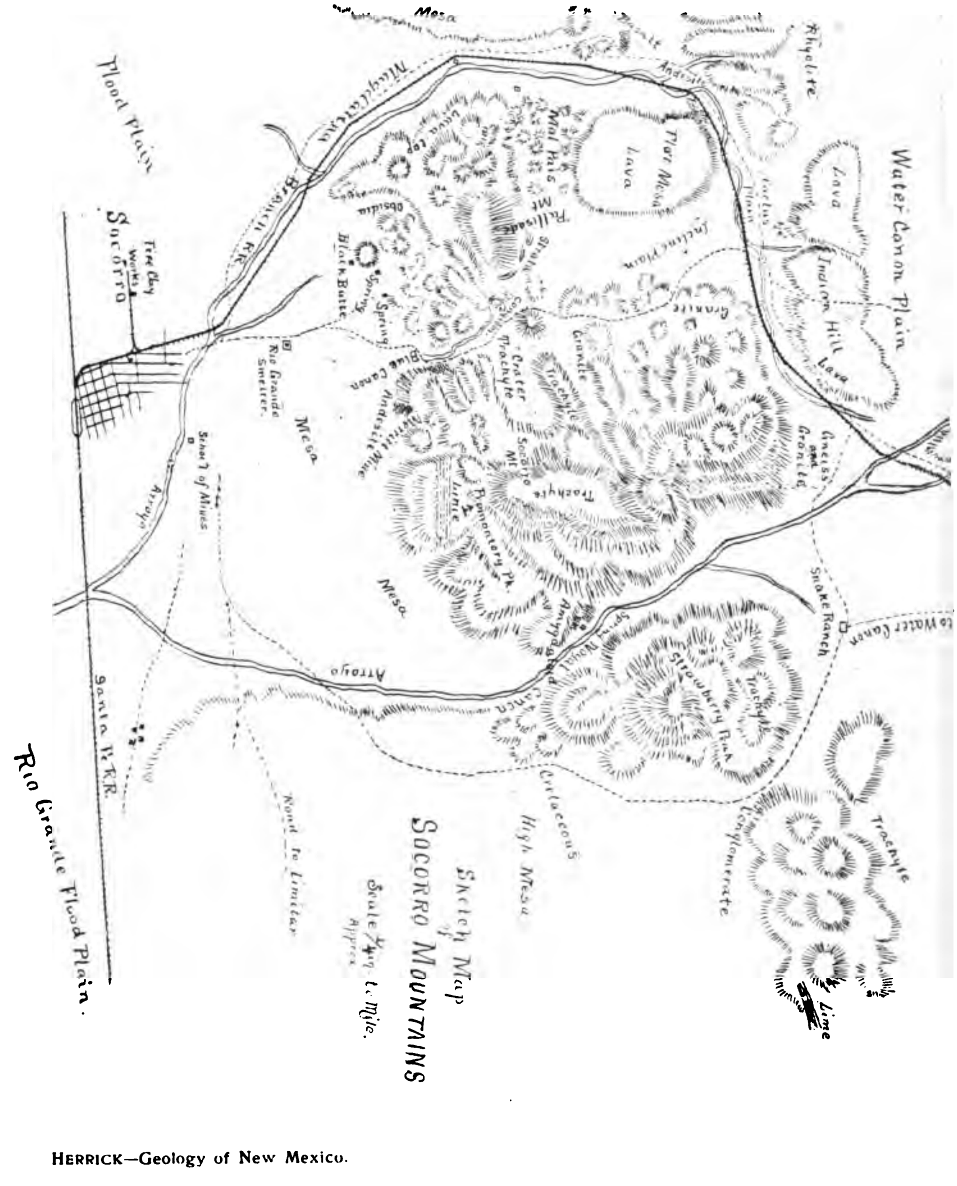
EXPLANATION OF FIGURES TO ARTICLE VI, VOL. I.

Fig. 1. Holbrookia maculata.
Fig. 2. Holbrookia texana.
Fig. 3. Holbrookia texana, top of head.
Fig. 4. Holbrookia texana, side of head.
Fig. 5. Holbrookia texana, anal armature of male.
Fig. 6. Sceloporus poinsetii.
Fig. 7. Sceloporus poinsetii, ear armature.
Fig. 8. Sceloporus poinsetii, top of head.
Fig. 9. Sceloporus magister.
Fig. 10. Sceloporus magister, top of head.
Fig. 11. Sceloporus magister, ear armature.
Fig. 12. Sceloporus occidentalis.
Fig. 13. Sceloporus occidentalis, top of head.
Fig. 14. Sceloporus occidentalis, anal aamature of male.
Fig. 15. Phrynosoma douglassii.
Fig. 16. Phrynosoma cornutum.
Fig. 17. Phrynosoma, position of nasal opening.
Fig. 18. Phrynosoma platyrhynus.
Fig. 19. Uta stanisburiana.
Fig. 20. Crotophytus collaris.
Fig. 21. Crotophytus collaris.
Fig. 22. Cnemidophorus sexilineatus, genital plates of male.
Fig. 23. Cnemidophorus sexilineatus.
Fig. 24. Cnemidophorus sexilineatus, ventral aspect of forearm.

ERRATA.

The authors of the article on Lizards of New Mexico do not wish to be held responsible for the fact that the specific names in the titles are capitalized but confess to the comma seperating the specific name from the authority. In explanation of the latter, in spite of various usage and authority for the omission of the point, we preferred to obey the unambiguous dictates of rhetoric rather than the divided and arbitrary authority of zoologists.

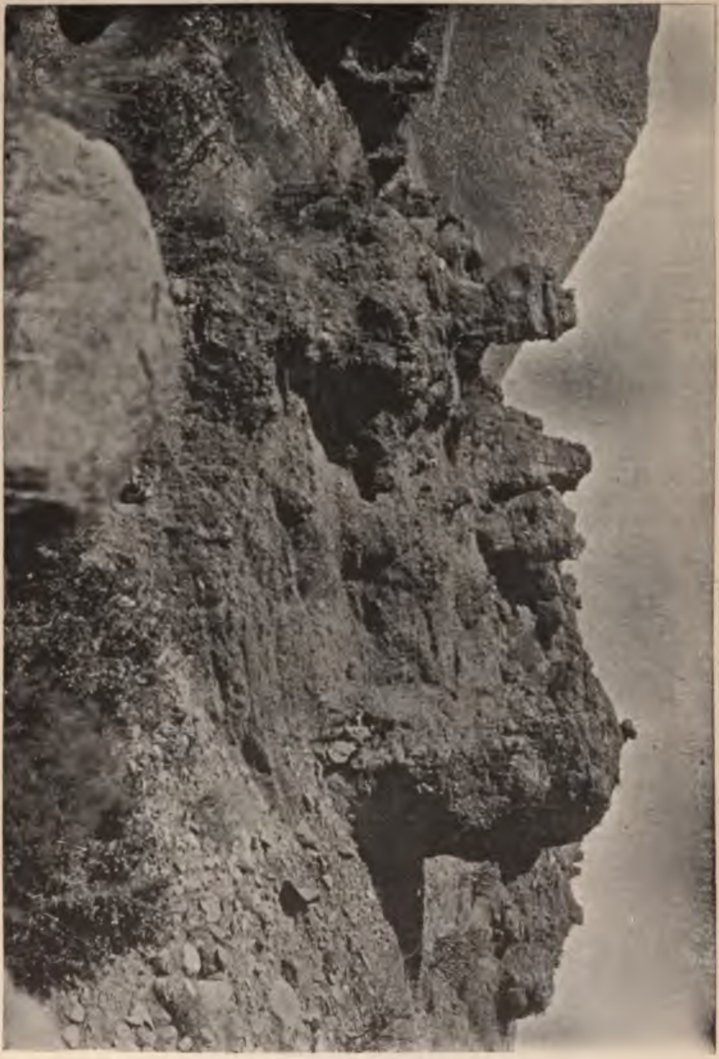
On page 126, line 2, instead of Scelopus, read Sceloporus.
On page 145, line 3, instead of Sexilieatus, read sexilineatus.
On page 146, line 1, instead of sexlineatus, read sexilineatus.
Plate XVI, instead of MAJISTER read MAGISTER.



Sketch Map of SOCORRO MOUNTAINS

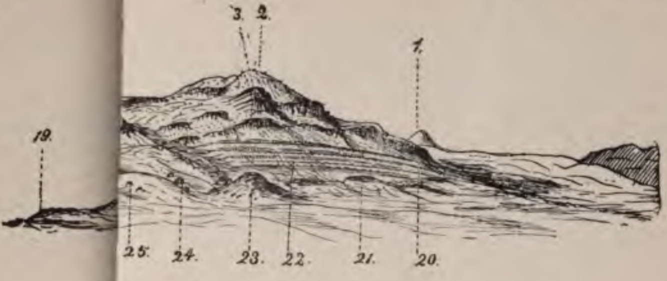
Scale 1/4 in. to Mile. Approx.

HERRICK—Geology of New Mexico.



HERRICK—Geology of New Mexico.

CASTELLATED PEAKS SOUTH OF BLUE CANON ROAD.



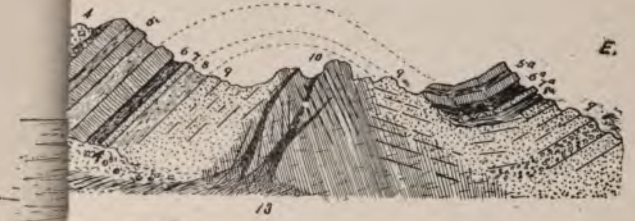


Fig. 5.

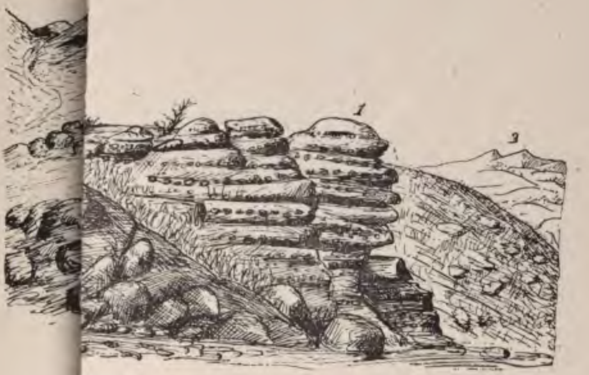
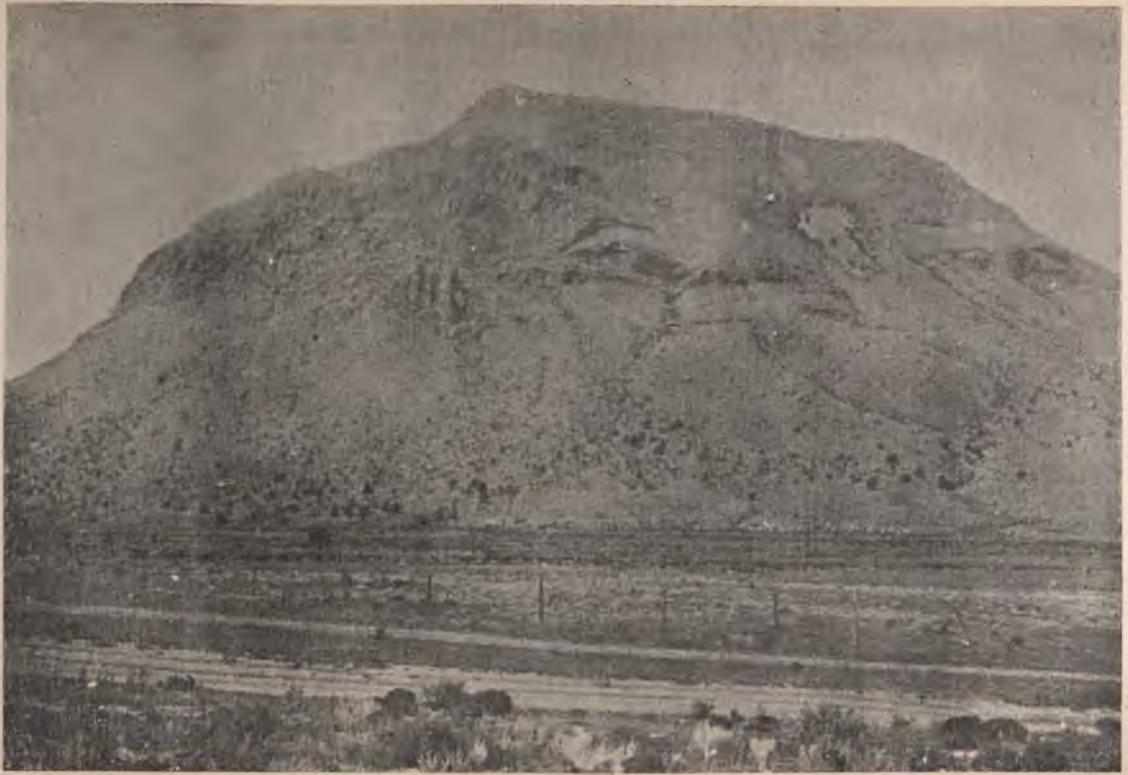


Fig. 2.

HERRICK—

te, rhyolite and breccia flows; 14. Pallisade Moun-
The f fied gravel and sand covered with a thin flow of re-
hytic rock over the limestone; 21. Quartzite at base
tains i ous limestone, about 400 feet thick; 24 to 26. An-
other mines; 27. Beds of kaolin from decomposition
series . Blue Canon; 30. Rio Grand smelter; 31. Spring;
placed ch; 34. Clay.
in the hrough the axis of uplift south of Limitar mountain.
this a nated margin of trachyte; 3. Porphyry about the
a dyk act zone; 5. Massive limestone; 6. Shale with Pro-
discov feet); 8. Shaly limestone with Spirifer camerata;
and w next; 10 Mica and hornblende schist with quart-
Weste Granite; 13. Diorite, intrusive (paramorphic); 14
ern w ar the crater.



HERRICK—Geology of New Mexico.

MAGDALENA MOUNTAIN.

PLATE XIII.

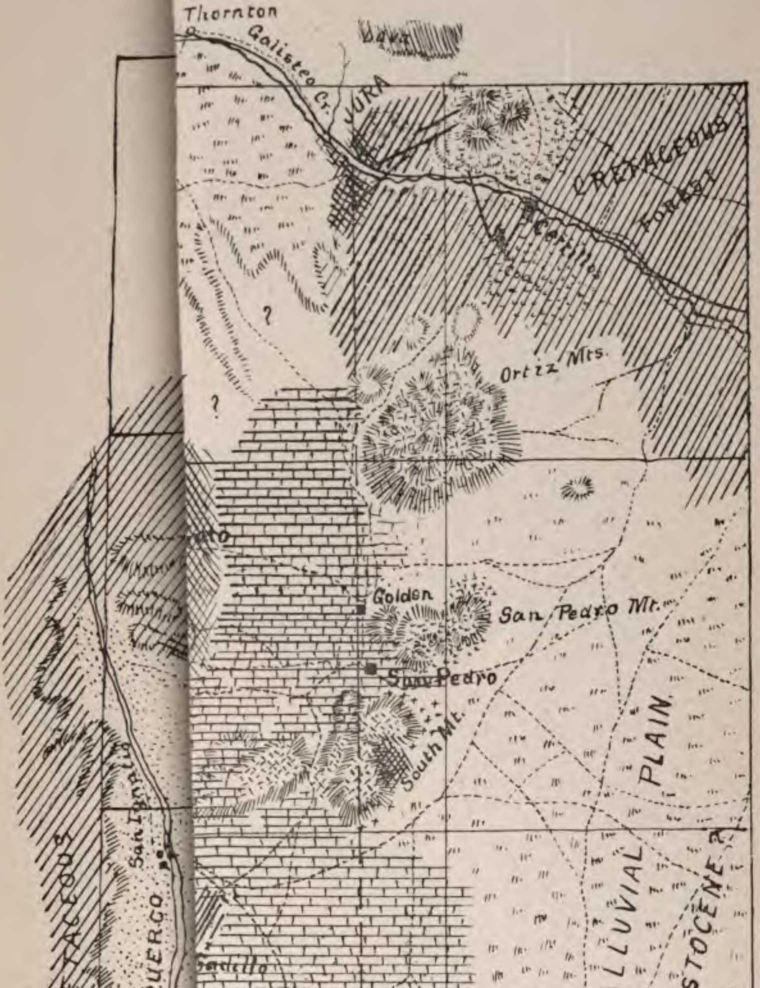

Thornton
Galisteo Cr.
Lava
JURA
CRETACEOUS
FOREST
Cerrillos
Ortiz Mts.
?
?
Golden
San Pedro Mt.
San Pedro
South Mt.
PLAIN
ALLUVIAL
PLEISTOCENE ?
CRETACEOUS
San Ignacio
RIO PUERCO
adillo
RBONIFEROUS
Fl
Granite : Andesite Carbonif.

PLATE XIV.

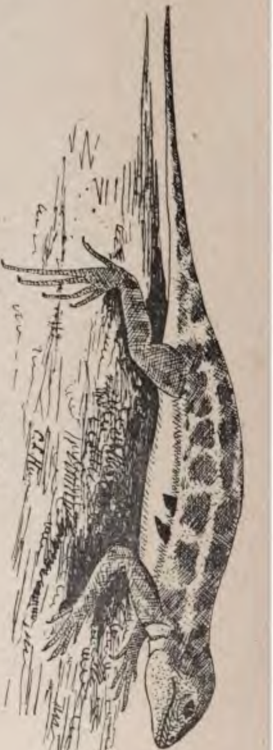


Fig. 1.

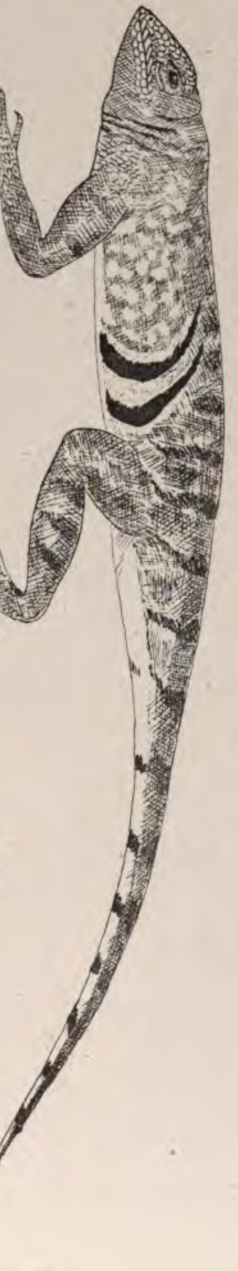


Fig. 2.

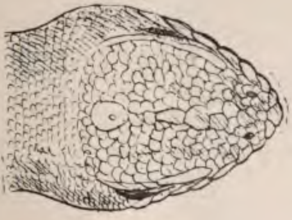


Fig. 3.

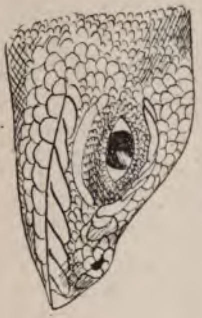


Fig. 4.

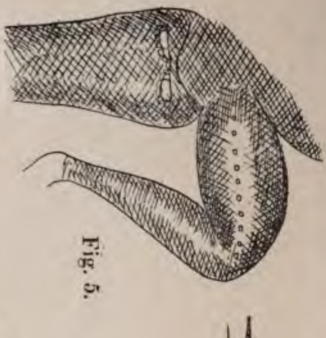


Fig. 5.

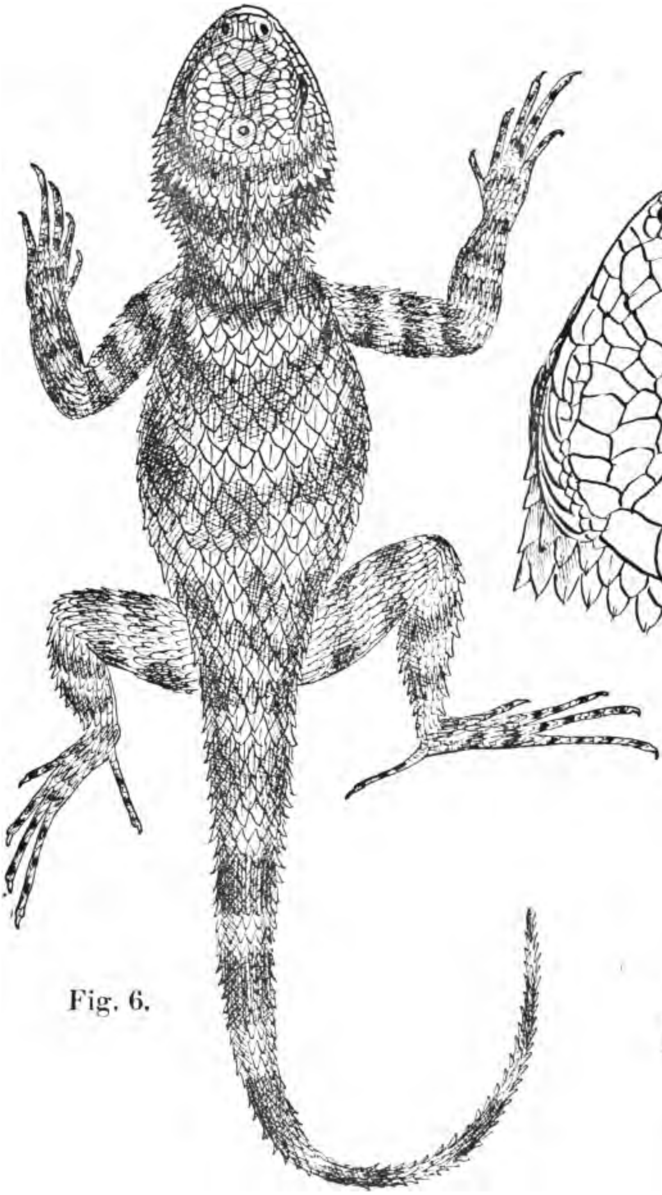


Fig. 6.

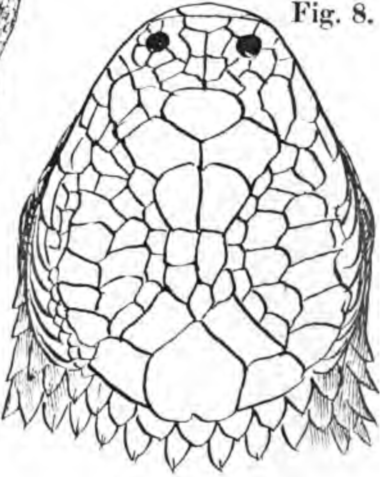


Fig. 8.

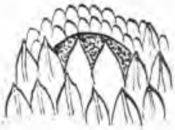


Fig. 7.

HERRICK—Lizards of New Mexico.

SCELOPORUS POINSETTII.

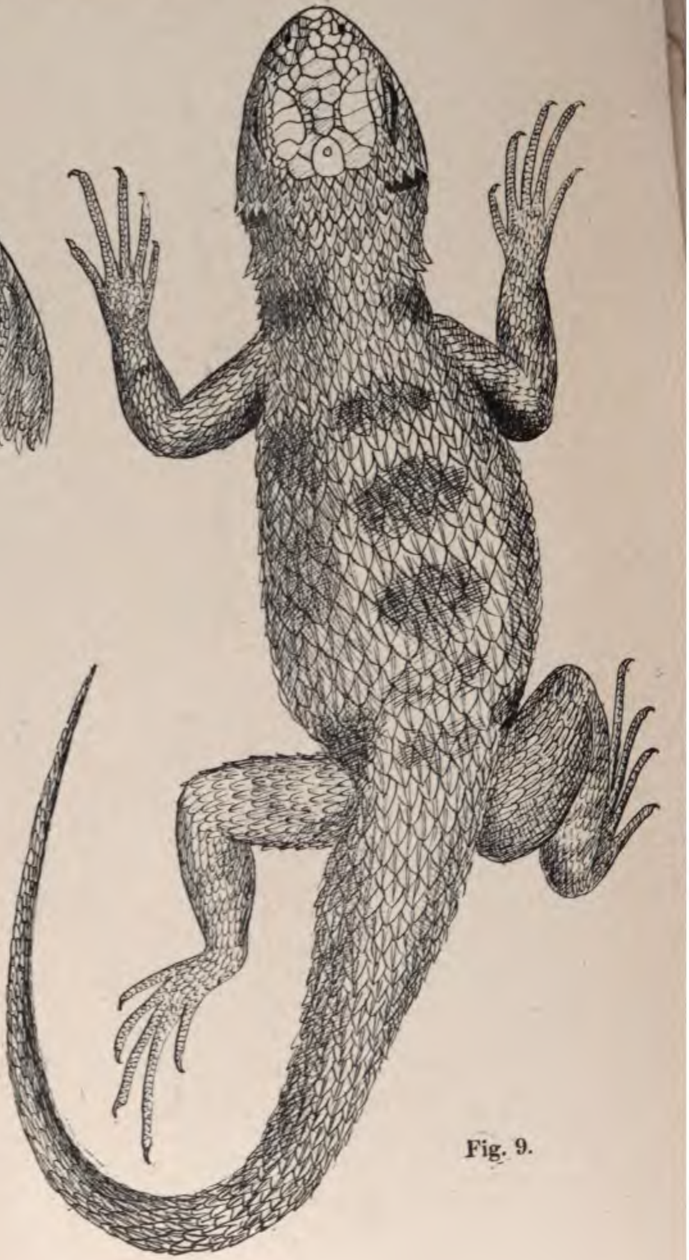


Fig. 9.

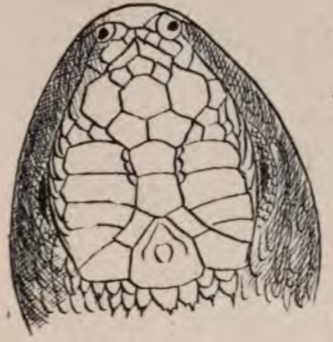


Fig. 10.

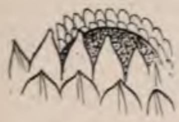


Fig. 11.

SCELOPORUS MAJISTER.

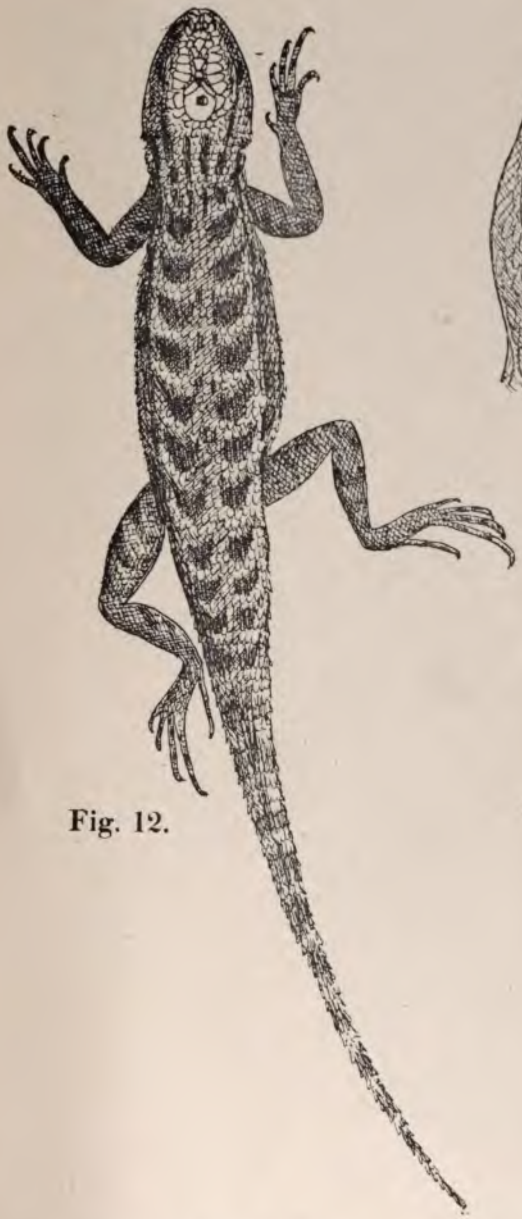


Fig. 12.

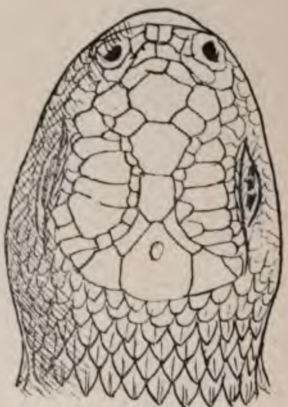


Fig. 13.

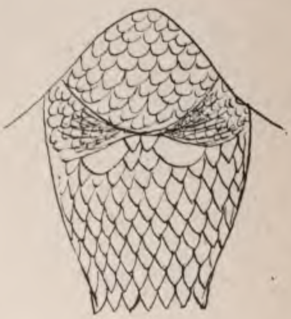


Fig. 14.

HERRICK—Lizards of New Mexico.

SCELOPORUS OCCIDENTALIS.

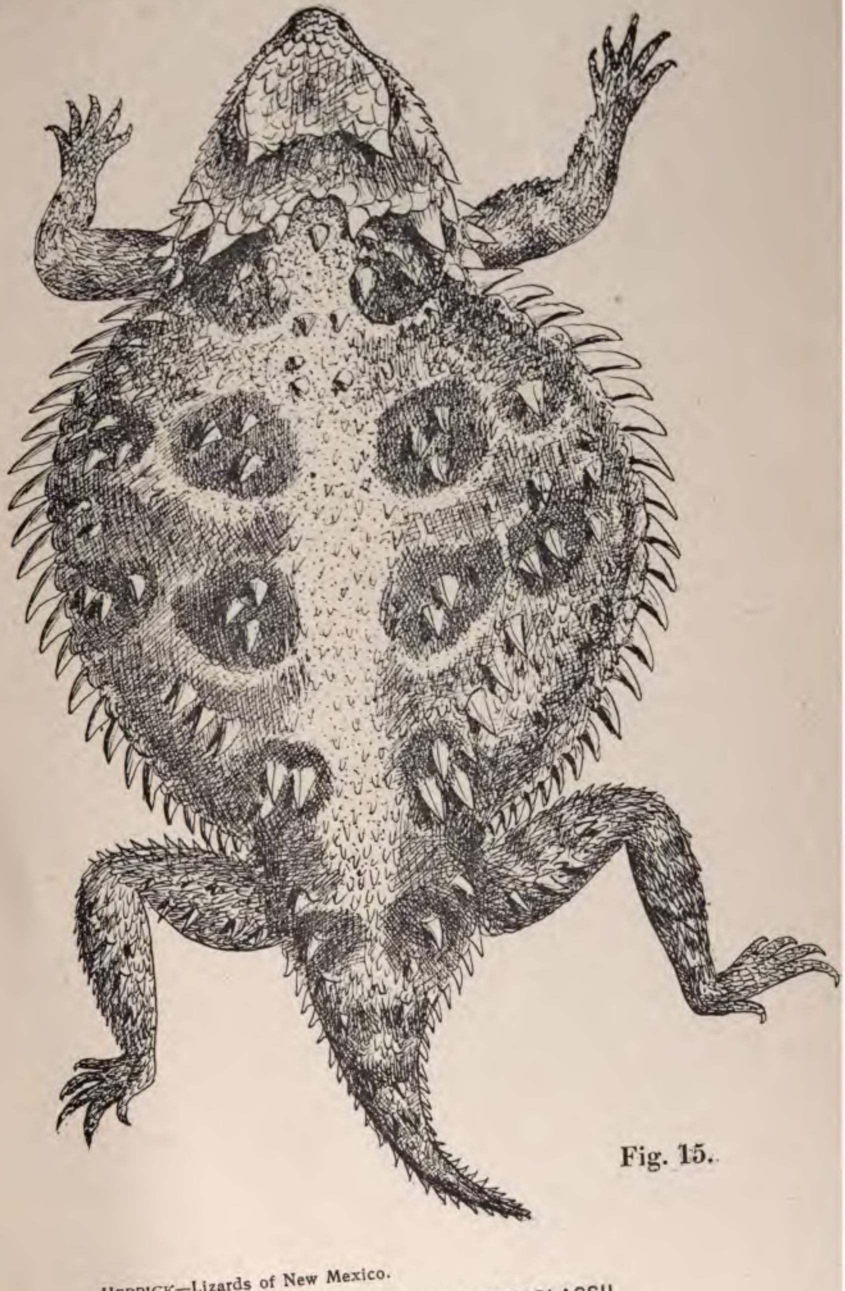


Fig. 15.

HERRICK—Lizards of New Mexico.

PHRYNOSOMA DOUGLASSII.

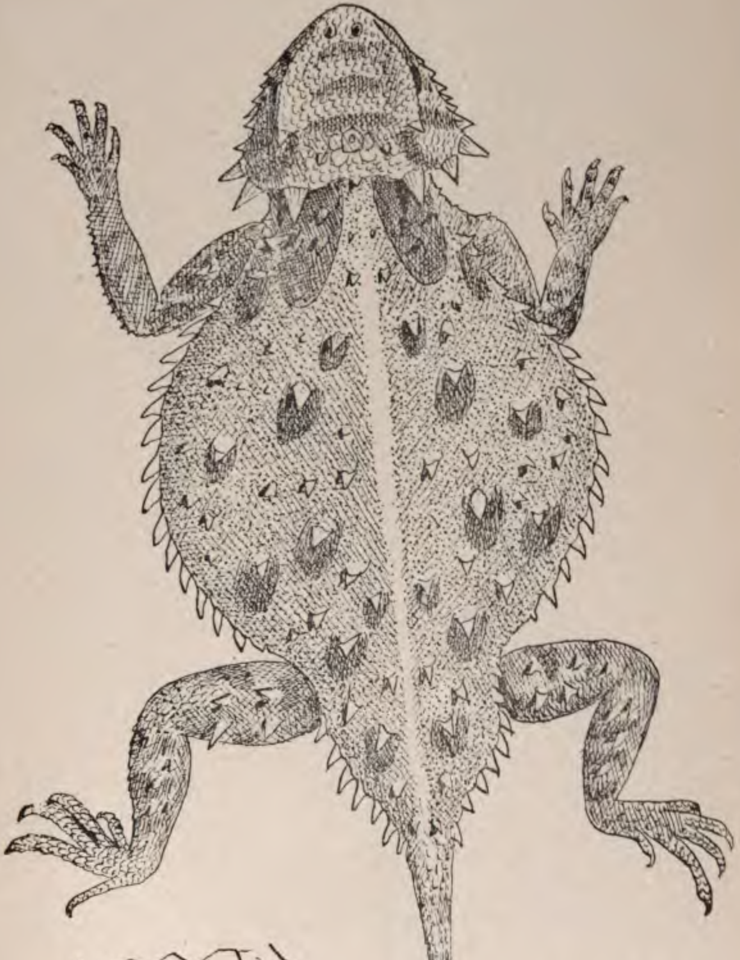


Fig. 16.

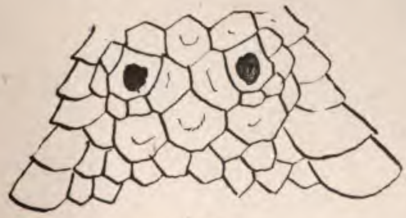


Fig. 17.

HERRICK—Lizards of New Mexico.

PHRYNOSOMA CORNUTUM.

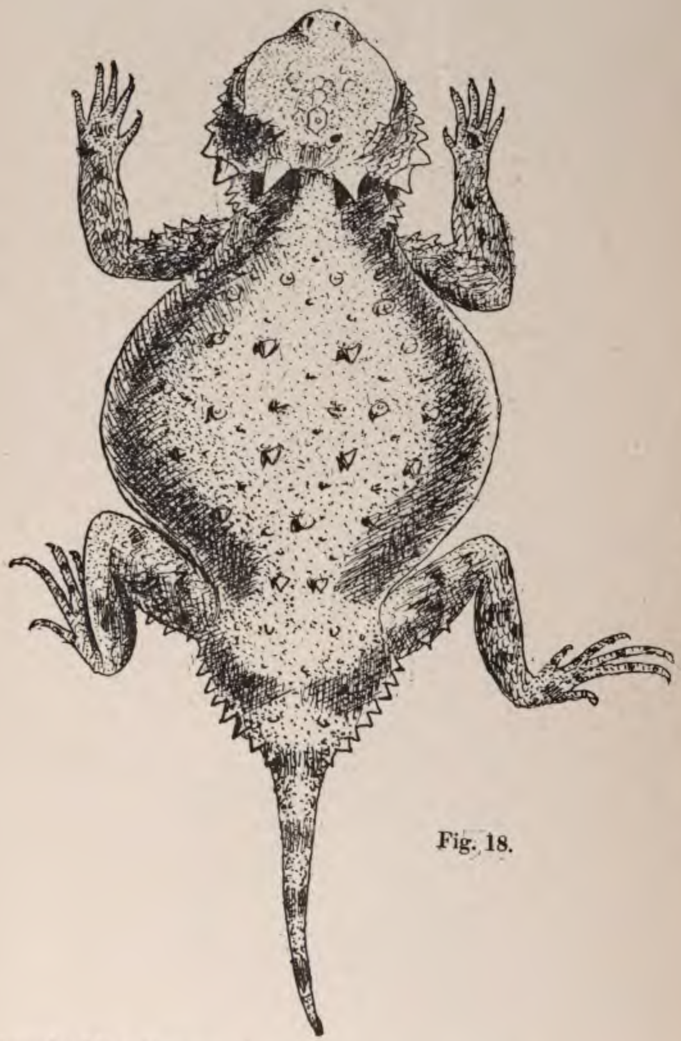


Fig. 18.

HERRICK—Lizards of New Mexico.

PHRYNOSOMA PLATYRHYNUS.

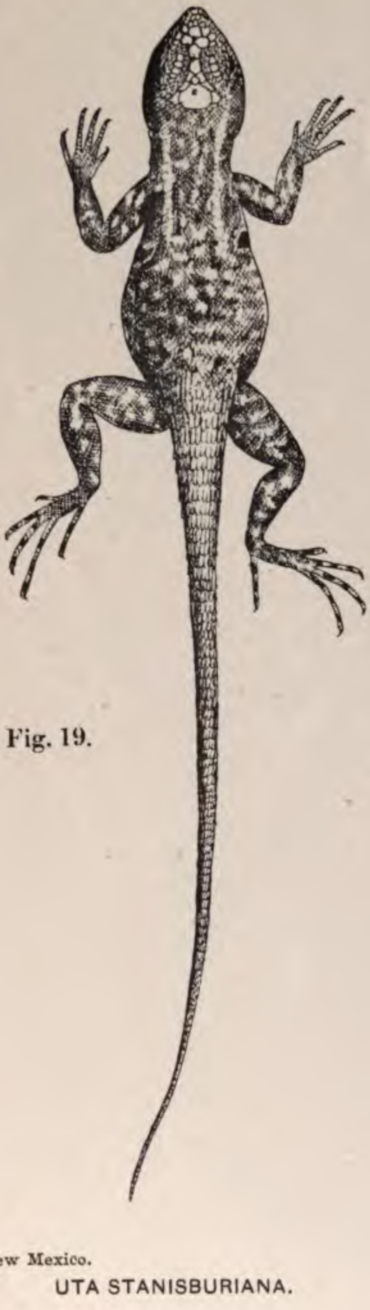


Fig. 19.

HERRICK—Lizards of New Mexico.

UTA STANISBURIANA.

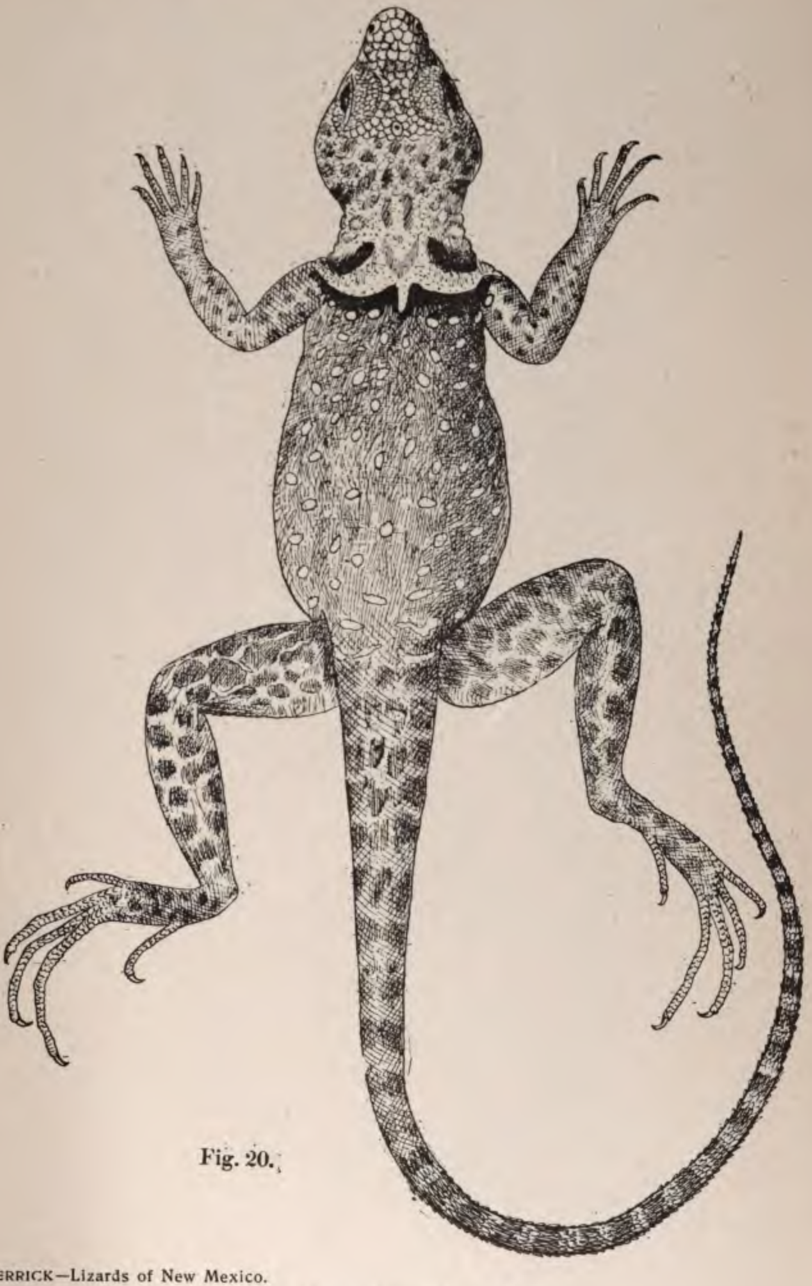


Fig. 20.

HERRICK—Lizards of New Mexico.

CROTOPHYTUS COLLARIS.

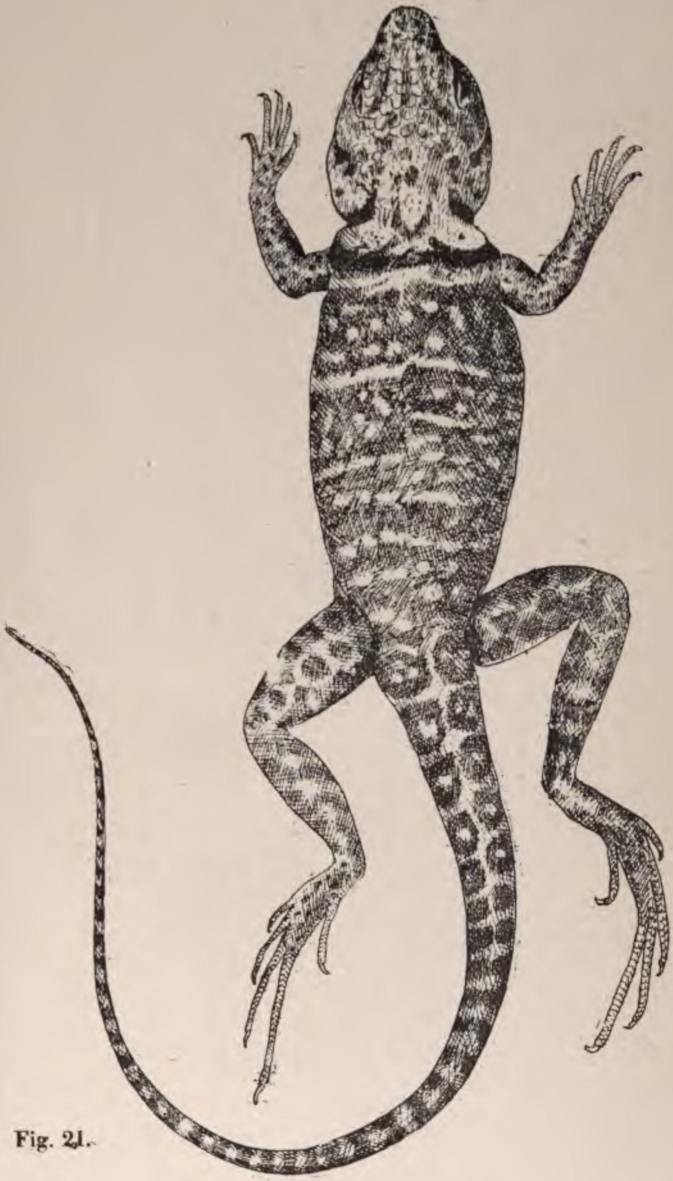


Fig. 21.

HERRICK—Lizards of New Mexico

CROTOPHYTUS COLLARIS.

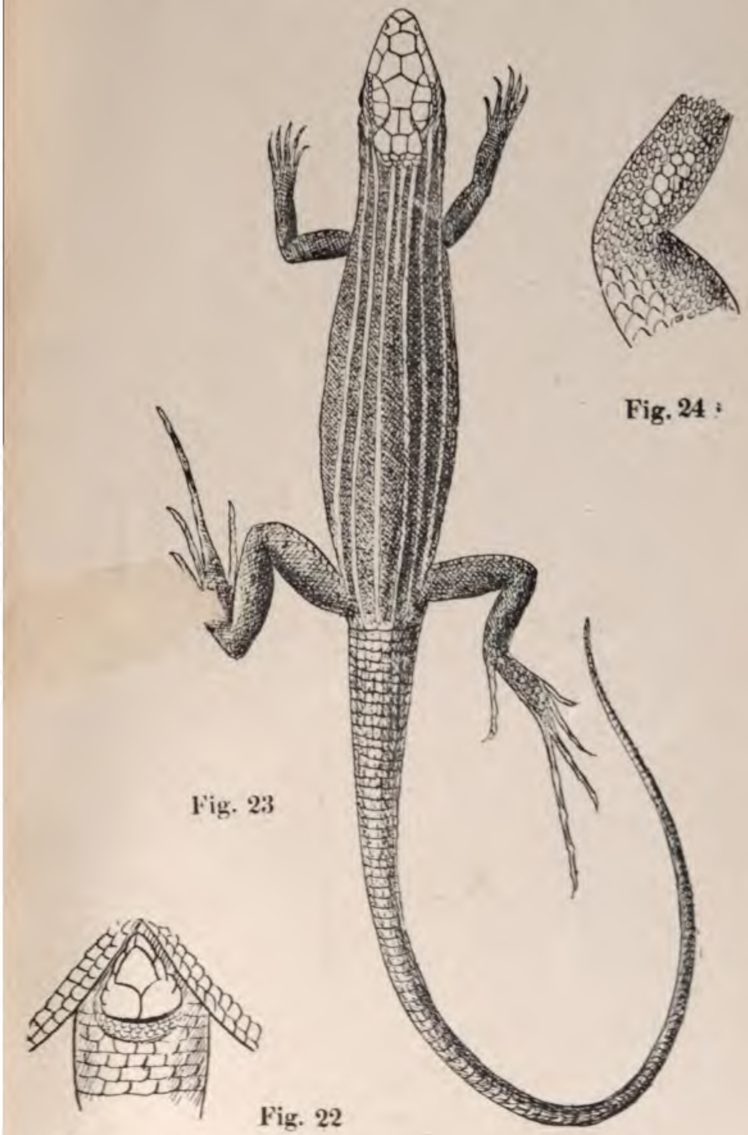


Fig. 24

Fig. 23

Fig. 22

HERRICK—Lizards of New Mexico.

CNEMIDOPHORUS SEXILINEATUS.

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